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LECTURES
ON
COMPARATIVE ANATOMY AND ANIMAL PHYSIOLOGY,

DELIVERED BY

ROBERT E. GRANT, M.D., F.R.S.E., &c., &c.;

Fellow of the Roy. Coll. of Physicians of Edin., and Professor of Comparative Anatomy and Animal Physiology in the University of London.

LECTURE XLVIII.

ON THE SANGUIFEROUS SYSTEM IN THE MOLLUSCOUS CLASSES.

THE slow-creeping molluscous animals drag on a languid existence, without feeling, without enjoyment, from the imperfect development of all their higher organs of relation or of animal life. Their organs of nutrition or of vegetative life, are developed at the expense of all those higher systems which give to the articulated classes their redundance of life and activity. Indeed these two great systems of animal organization follow generally an inverse ratio to each other in the march of their development in each class. We have seen the superiority of the mollusca in the extent and development of all their digestive apparatus, and we observe the same in their glandular organs, and in all their other systems connected with individual nutrition, but there is no part of their economy in which they manifest a greater superiority over the articulated classes than in their vascular system. It is the restless activity of the worm and of the insect, that makes every fibre of their body as a heart to propel their blood and circulate their fluids. They require no complicated apparatus to accelerate the ever-active currents of their blood, and hence the imperfect development of the great centre of their vascular system. Indeed it has been shown by EHRENBERG and by NORDMANN, that in the simplest of these animals, the trematoid entozoa, the blood flows through the system by the mere motions of the body, without the least motion or impulse from the vessels which contain it. The great centre of their vascular system has not yet developed even into a pulsating vessel—the first rudiment of the human heart; but it is still membranous, fibre-less, motionless, and inert as the cell of a *chara*. And what have we in the highest of these articulated classes, even in the active powerful carnivorous decapods, but the dorsal vessel of the worm and of the insect concentrated into a pulsating sac? They require no more, for every muscular member of their restless body is as a heart to keep the blood in constant motion. How differently circumstanced are the mollusca!

The inert tunicata, the lowest of the molluscous classes, fixed like plants upon the sea-beaten cliffs, and in which we can scarcely discover a trace of life, enclose in their motionless carcass a heart as highly developed as that of the crustacea, the highest of the articulated classes; and if they did not, their blood would stagnate in the complicated labyrinth of vessels and organs through which it has to pass. The slow-creeping snail that feeds upon the turf, has a heart as complicated as that of the red-blooded vertebrated fish which bounds with such velocity through the deep. It is because the fish is muscular and active in every point that it requires no more heart than a snail to keep up the necessary movements of its blood. It is beautiful to trace the order followed by nature in the development of organs throughout the animal kingdom, or in the microcosm of our own body; but it is surpassingly beautiful to discover the reason and end of nature in establishing that order of development.

The harmony of these arrangements is sometimes obscured by the language in which they are described; for if we give ten

auricles and ten ventricles to an *earth-worm*, and only a dorsal vessel to an *insect*, if we give two auricles to the *cephalopods*, and only one to the *fishes* and the tadpoles of *amphibia* above them in the scale; if we give two auricles and a ventricle to a *cockle*, and the same to a *frog* and a *lizard*; if we say that there are two auricles and two ventricles enclosed in the shell of an *arca*, and no more in the human body, how can we perecive a trace of that perfect order which is preserved throughout in the development of this vascular system? The kidneys, the pancreas, the spleen, the liver, the stomach, the bones, the brain itself, and most of the organs of the body, begin their career in the inferior tribes by the formation of numerous detached portions, and mark their increasing development and internal elaboration by their more concentrated forms in higher classes of animals. The same is observed in the sanguiferous system, and we might as well, counting the lobes as organs, give a hundred kidneys to a fish or a reptile, as eight ventricles to an insect or ten auricles to a worm. There is an auricle in animals for the systemic blood, and an auricle for the blood which has passed through the lungs. This second auricle does not begin its development, however, with these low, water-breathing, slow-moving mollusca, but with the more highly-organized and more active air-breathing vertebrata, as has been shown by Weber in the perennibranchiate amphibia, the *axolotl* and the *proteus*, the lowest of the air-breathing vertebrated animals.

There is no heart in the cells of the plant, nor in the vascular system of the lowest animals, to interrupt the smooth regularity of their revolving streams, which may be produced by cilia invisibly minute. The heart begins by a muscular pulsating portion of the great trunk of the vascular system in most of the echinoderma, which we have seen developed into a strong, circumscribed, fleshy, systemic ventricle, in tracing it through the articulated classes to the crustacea. But while this muscular cavity, by its increasing development, accelerates the flow of the blood, it interrupts the smooth regularity of the stream, especially in its own vicinity, where the current of the returning venous trunk must be interrupted during every contraction of the ventricle, when alone developed. This interruption to the free passage of the blood by the contraction of a single ventricle in its course, produces or necessitates the development of a new cavity or sinus behind the ventricle, to receive the rapid current of returning blood, and allow it to accumulate while the ventricle contracts. Thus originates a new cavity of the heart, the systemic auricle, which presents itself under various forms from the lowest *tunicata* throughout the molluscous classes. It is an enlarged portion of the muscular and contractile part of the venous system. Destined to accumulate the blood for the great and restless cavity of the ventricle, and to relieve the returning veins during its contraction, this auricle may consist of as many portions as there are venous trunks, and we generally find it divided in the acephalous mollusca. But the function of these portions is the same, and the organ is single, till the commencement of a new circulating system of vessels for aerial respiration among the vertebrated tribes requires the development of a new auricle, and at length a new heart for itself.

Although the sanguiferous system of the mollusca is thus generally provided with a systemic auricle and ventricle, it presents considerable varieties, both in the form and structure of its great central parts, and in its general distribution through the system. These differences are chiefly dependent on the diversified forms of the body, the various positions and characters of the respiratory organs, and the increasing development of the whole frame as we ascend through the molluscous classes. Their blood is still thin, colourless, and transparent, containing less of the fibrinous part, and is less coagulable than in the red-blooded classes of vertebrata. It has a bluish-white colour and great transparency in the living state, but becomes more white and opaque when coagulated out of the body.

In the lowest class of molluscous animals, the *tunicata*, the circulating system still presents a very simple condition of its central parts. We observe in the *ascidiæ*, at the bottom of the abdominal cavity, below the respiratory sac into which the water is conveyed for respiration, between the stomach and the parietes of the muscular coat, that there is a distinct pericardium, containing a dilated portion of the vascular system, which upon being examined in the living state, was distinctly observed by Dicquemare to pulsate. It consists of a thin lengthened ventricle with a minute auricular sac. This organ receives the blood from the respiratory folds, the gills, disposed in numerous highly vascular laminæ on the interior of the respiratory sac. It conveys this blood backwards between the stomach and the mantle, and the great aortal trunk which is seen to arise from the ventricle of this heart, makes a sudden curvature, and then ascends along the abdominal parietes in the direction of the intestine.

Delle Chiaje thinks there are two rudimentary auricles in the ascidiæ, as in most of the conchifera. This whole heart, however, is a mere enlargement of the great arterial trunk, which is muscular and pulsating like the corresponding part in the *echinoderms*, and it appears more probable that Cuvier, Savigny, and Meckel, are correct in considering this auricle as a single minute cavity, partially separated from the thin transparent fusiform ventricle. This auricle and ventricle receiving the arterialized blood from the branchial folds and propelling it through the system, form a systemic heart, like that of the simpler tribes through which we have passed, and like that of the conchiferous animals with which they are most closely allied. The position of the heart with relation to the alimentary canal in these tunicated animals is also nearly the same as in the conchifera; for if we invert this *cynthia* (*Fig. U* 1, Vol. I. p. 426), and place the respiratory sac on the lower abdominal surface as in most of the bivalvia, we find the vascular system occupying as usual the upper dorsal region of the body (*Fig. U*, 1 *d*, Vol. I. p. 426).

The circulating system of the conchifera presents a more complex condition in all its parts than in the tunicata. All the conchiferous animals, as all the tunicata, are aquatic animals, breathing by means of branchiæ. The blood which has been sent through the system, returns in a venous condition, and by numerous anastomosing veins, uniting into larger and larger trunks, it is propelled in whole or in part through the pectinated laminæ of the gills. Exposed to the influence of the oxygen of the air contained in the water, the blood becomes oxygenated and decarbonized, and rises by numerous trunks from the respiratory organs, which, anastomosing, and uniting into larger and larger vessels, enter two thin cavities of the heart, one upon each side of the ventricle, and generally in the region of the back. Those two cavities constitute the two auricles or the two portions of the systemic auricle, which we see so constant in these conchiferous animals. Those two lateral cavities of the heart are thin, muscular, contractile sacs, that have precisely the same functions to perform upon each side of the body. For considering these two cavities as distinct auricles, some have imagined there was an analogy between the two cavities of the heart of the conchifera and the two auricles of reptiles. But by adopting a view of this kind, one might be led to suppose that the same order and regularity were not perceptible in the development of the vascular system in the lower tribes of animals which is observed in the nervous and other systems; for it might thus be imagined that in passing up through the animal kingdom, we ascend from animals with a single cavity in the crustacea suddenly to animals with three cavities of the heart in the conchifera, and probably even in the tunicata, according to Chiaje; then that we ascend to gasteropods with only two cavities of the heart; then to pteropods, with a more simple structure; then to cephalopods, with three cavities of the heart; then that we go still higher to fishes, and meet with only two cavities of the heart; then that we come to animals with three cavities: and so there appears in adopting this view to be no perceptible method or order in the development of the vascular system in the lower animals. In the *lingula*, among the brachiopodous bivalves, the ventricle is divided into two sacs, placed apart from each other, and without auricles, as you observe in these plates of Cuvier. There is properly but one auricle, however, in the conchifera; that auricle, in order to be more accommodated to the particular form of the body, and especially the lateral position of the gills, is divided into two lateral parts, and placed one upon each side, but these two separate portions of the auricle have precisely the same functions; this is not the case in those higher animals, where we find two distinct auricles of the heart developed. For instance, in amphibia and reptiles there are two distinct auricles of the heart, having very distinct functions, and one ventricle. The one auricle, as shown by Dr. Davy in the amphibia as well as in the reptiles, is pulmonic, and the other is venous. This is not the case, however, with the two cavities of the auricle in the conchifera. There is but a single ventricle in the conchifera, which receives the aerated blood from the two auricles, and propels that blood by two great aortal trunks, both forwards and backwards, through the system. This ventricle lies longitudinally, has two valves at the openings of the auricles, has thick muscular parietes, and is generally pierced by the intestine, which passes through its cavity near to the rectum. The bulbus arteriosus is already apparent on the origin of the aorta in many of these conchifera, and is still more developed in some of the gasteropods and cephalopods; it continues its development through the fishes, amphibia, and reptiles, and is a preparation for the division of the aorta into a systemic and pulmonic trunk.

The division which you witness in the auricles of the heart, is partly witnessed also continued through the ventricle of the teredo and other conchifera. That you can see in this figure of the *teredo*

nasalis, where you observe the two great branchial veins bringing up the blood that has been arterialized in the gills, to the two long narrow fusiform auricles, and from these two auricles passing into a stronger muscular pulsating cavity, which behind is partially divided. You can see very distinctly in this common oyster, where the body is narrow, and is much expanded longitudinally and vertically, that the two auricles, of a dark colour and soft spongy texture, have united together into one, and pour their contents by two short canals into a broad, white, round, muscular, single ventricle, which is not pierced by the intestine, as this ventricle is in most of the conchifera. When I open this white fleshy ventricle of the oyster, situate below the adductor muscle of the valves, and look down upon the two openings from the very broad, united, black-coloured auricles, distinct prominent valvular folds are seen extending from the margins of these two venous orifices into the cavity of the ventricle. Similar valves are described by CHIAJE in the heart of the *ascidiæ*, but his account of the circulating system of the tunicata is inconsistent with every analogy, and differs from that of all other observers, especially in the direction assigned to the currents of the blood and to the valves. Not only is the auricle divided into two in the *area noæ*, but this bifurcation extends through the ventricle, and thus an appearance of two hearts is produced, each provided with its two lengthened cavities, an auricle and a ventricle; and these two hearts are placed so laterally, that they are separated from each other by the whole breadth of the animal's body. These two halves of the heart are symmetrical in structure, and similar in function, as in other conchifera, and the whole organ is here necessarily divided into two, to be accommodated to the broad form of the animal's body, and to the distance which necessarily intervenes between the branchial laminæ and between the branchial veins. The heart has sometimes small supplementary sinuses, besides the two auricles, as figured here by POLI in his splendid plates of the *pinna*. The ventricle is, most generally, a thick, fleshy, single, round cavity, receiving the arterialized blood from two lengthened thin auricles, placed one on each of its sides, as you see in these large drawings of the *mactra* and the *cardium*. The beginning of the two aortal trunks, which issue forwards and backwards from this single ventricle, are generally traversed for a short distance, like the ventricle itself, by the intestine. The posterior aorta is found to be distributed chiefly on the mantle and the superficial parts, while the anterior great aortal vessel supplies the internal organs and the foot. Enlargements are occasionally seen on the great vascular trunks in the conchifera, as here figured by POLI on the great aortal trunk of the *venus chione*, at some distance from the ventricle. Similar developments on the great vascular trunks are met with in other molluscous classes, especially in the gasteropods and the cephalopods. In the spondylus the blood distributed on the mantle is brought back by two lateral veins to the two auricles, without having passed through the branchiæ, and indeed this ciliated organ, the mantle of conchifera, is almost a respiratory apparatus, by its high degree of vascularity, its cilia especially on its fimbriated marginal parts, and by its extensive exposure to the surrounding element. The same direct passage of the venous trunks of the mantle into the two distant auricles of the heart, in the *area noæ*, is described both by POLI and by CHIAJE, and is figured in these large plates. So that the sanguiferous system of these conchiferous animals does not form a complete double circulation, the whole of the venous blood of the system not being sent through the gills; and it has been observed by TREVIRANUS, that a part of the arterialized blood, returning from the branchiæ by the branchial veins, is sent through a soft pulpy organ considered as a kidney, before it reaches the auricles of the heart. This organ receiving a portion of the blood, according to TREVIRANUS, directly from the branchiæ, before reaching the heart, to be distributed through the system, was considered by BOJANUS as a supplementary respiratory organ, receiving a part of the blood of the system on its way to the gills, while VAN DER HOEVEN regards it as a receptacle for the blood going to the gills, like the lateral branchial hearts of the cephalopods, and the lateral branchial sinuses of the crustacea.

There is generally a greater simplicity of outward general form in the sanguiferous apparatus of the inhabitants of univalve spiral shells than we have seen in that of the conchifera, but there is a greater perfection or elaboration of all the parts of this system in this higher class of molluscous animals than in any of the acephala. In the gasteropods we find animals possessing the most diversified forms of the body, and respiring by very different organs and means. Some are inhabitants of the fresh waters, some of the sea, and some breathe atmospheric air upon the land; yet it is remarkable to observe the consistency of the simple and

single condition of the heart, and its uniformity with regard to the existence of two systemic cavities, one auricle and one ventricle. This is not a more simple or inferior structure, when examined in detail, than that of the vascular system, which we have seen in the conchifera. The two separate portions of the auricle of the conchifera are here almost always more conveniently approximated and united into one in the gasteropods, than they could be, from the position of the gills, in the former class. The blood, which has circulated through the system of the gasteropods, is collected by numerous anastomosing veins, and propelled, as in the conchifera, through the respiratory organs, whether they be in the form of pectinated laminæ enclosed in the cavity of the mantle, or branchial tufts exposed on the surface of the body, or air-sacs concealed beneath the mantle, or fringed margins extending round the body. From these respiratory organs, through which the venous blood of the system is freely circulated, it is collected by the branchial or pulmonary veins, which lead it, most generally, to a single thin auricle, but distinctly muscular, and often exhibiting in its interior even minute fleshy columns; but never so thick and columnar, or fasciculated in its parietes, as we see the white muscular ventricle, which, as well as the auricle, is provided with more complete valves than we see in inferior classes. The ventricle of the gasteropods, for the most part, has an angular, and often a triangular or pyramidal form, like that so common in fishes, and along with the auricles is enclosed in a distinct pericardium. This ventricle is single throughout the class, and propels the blood through the system. Although we see, as a normal character of these gasteropods, that the blood collected from the system is conveyed through the gills, and from this is brought into a single auricle, and thence into a single ventricle to be propelled through the system, there are many modifications of this general plan, which point out affinities both with the inferior and with the higher forms of molluscous animals.

The arterialized blood, returning from the two long pectinated branchiæ in the *haliotis*, is conveyed by the two branchial veins to two lengthened auricles placed on the left side of the body. These two auricles very much resemble in form those of most of the conchifera, and they pour their blood into each side of a lengthened fusiform ventricle, placed between them, provided with strong muscular parietes and fleshy columns, and completely surrounding the intestine, which passes through it in this gasteropod, as we see so commonly in the bivalved mollusca. The ventricle of the heart appears like an enlarged portion of the rectum, to the sides of which the two auricles are attached. All these cavities of the heart are enclosed in a distinct pericardium. It is from the posterior extremity of this perforated ventricle, the end which the intestine first enters, that we see the great aortal trunk given out in the *haliotis*; and this aorta passes suddenly inwards, at right angles to the heart, to give large branches to the abdominal viscera, to the round muscle of attachment, like that of a spondylus or an ostrea, which fixes the animal to its convex shell, and then the vessel is directed forwards to supply the parts of the head. This forms the nearest approach to the conchiferous mode of circulation met with in the gasteropods. A similar division of the auricle was shown by Poli in the *chiton*, and the same structure is seen in the *fissurella* and *emarginula*. This passage of the intestine through the heart, so constant in the conchifera, and which we see in several of the gasteropods, both testaceous and naked, may be a means of adding further nutriment to the blood by exostose through the intestine where the absorbent system is so imperfectly developed; or it may afford a means of excreting some material from that fluid into this anal portion of the intestine, before it is distributed for the nourishment and repair of all parts of the body; and it is very obvious that the constant contractions of the muscular ventricle surrounding this inert part of the intestine, generally charged with the residue of digestion, must mechanically assist the passage of that matter through the canal. The rectum is enveloped by the auricle in the *doris*, but it pierces the ventricle in the *fissurella* and the *emarginula*.

The single auricle and ventricle which we find in most of the gasteropods, are situated near to the respiratory organs from which they receive the aerated blood, and their position in the animal's body is therefore chiefly dependent on the situation of these most variable and ubiquitous organs. These are the most influential organs over the forms of the vascular system, and they vary so much in their form, position, and nature, in the gasteropods, that the subdivision of this very extensive and interesting class into orders, is founded on the characters presented by these mutable respiratory organs. In the naked *tritoniæ*, the branchiæ are extended along the sides of the upper part of the body, and the heart is placed between them in the middle of the back, from which the great aortal trunk, passing forwards, sud-

deuly divides into three principal branches, the posterior going to the genital organs, the middle branch to the digestive, and the anterior large trunk to the muscular and sensitive organs on the fore and lower parts of the body. Now in the pectinibranchiate gasteropods, which inhabit turbinated spiral shells, the generative and intestinal orifices are placed on the right side of the body, while the canal of the shell, the respiratory syphon of the mantle, and the branchiæ themselves, are situated on the left side; and as the heart is always placed close to the base of the branchiæ, so as to receive by one great branchial vein, opening into the auricle, all the aerated blood to be sent backwards and forwards through the system by one ventricle and one aortal trunk, we find these cavities of the heart situated, like the branchiæ, on the left side of the body, and not, as stated by MECKEL, on the right side. This structure of the pectinibranchiate gasteropods, you observe in these large coloured drawings of the common *buccinum undatum* (*Fig. Z, g h*, Vol. I. p. 475), where two pectinated branchiæ of unequal size (*Fig. Z, g*) like those on each side of the *nautilus* among the cephalopods, are seen within the left base the thin small angular auricle, slightly marked with fleshy bands, which receives the blood from the branchiæ by one orifice, and transmits it to a very thick muscular round ventricle (*Fig. Z, h*), marked internally with strong fleshy prominent columns, and having two distinct semilunar folds, forming the usual auriculo-ventricular valve, in the situation of the mitral of mammalia. The single aorta proceeding from this ventricle, immediately divides into several large trunks, going forwards to the œsophagus, upwards to the large muciparous follicles, and backwards to the digestive and generative organs.

In the *doris*, one of the naked dorsibranchiate gasteropods, the heart is placed on the posterior part of the back, in consequence of the branchial tufts having that dorsal situation around the anus. The venous blood of the system is collected and transmitted by three great branchial arteries into the respiratory gills, from which it passes into a crescentic auricle, disposed around the rectum, which thus appears somewhat in the condition so common among the conchifera, where this part of the intestine is surrounded by the ventricle. The short, broad, round muscular ventricle of the doris, is placed before the auricle, and transmits the arterialized blood by a large median aortal trunk, forwards, along the back, to the head, giving numerous branches in its passage, to the liver, the intestine, the genital and other organs. From observing numerous interstices between the muscular bands placed around the two venæ cavæ of the *aplysia*, CUVIER imagined there was a free and extraordinary communication between the interior of these great systemic veins and the general cavity of the peritoneum lining the abdomen, and an analogous structure has been ascribed to the great systemic vein of the *nautilus*; but MECKEL, in numerous large recent *aplysiæ*, as well as in specimens preserved in spirit, has constantly found the inner serous lining of these veins entire, so as to allow of no anomalous passage of blood from them into the cavity of the abdomen between the exterior muscular bands, which bands do not even belong to the thin delicate veins, but to the surrounding muscular parts. The heart of the *aplysia* (*Fig.* 158, *m, n*, Vol. II. p. 710), which is one of the tectibranchiate gasteropods, with the gills placed on the right side of the body (*Fig.* 158, *k, l*), we observe to be placed nearer to the posterior than the anterior part of the animal, and on the right side. It consists of a wide round auricle, and a pyriform thick muscular ventricle, like that of many fishes. There is a lengthened enlargement on the great aortal trunk of the aplysia, in the situation of the ordinary bulbous arteriosus of vertebrated animals, which here extends on to the commencements of the hepatic and gastric arteries, and traces of this aortal enlargement we have already seen in the conchifera.

The circulating system of the pteropods is similar to that of the gasteropods in the structure and position of the heart, and in the general distribution of the bloodvessels. In the *clio*, the *hyale*, and the *pneumodermon*, the blood after passing through the branchiæ, situated externally, is collected by the branchial veins, and conveyed to a single auricle and a single ventricle, to be sent through all parts of the system. The heart is generally on one side of the abdominal viscera, being on the left in the *clio*, and on the right in the *pneumodermon* and the *hyale*. NOW CHIAJE is not correct in stating last year (1832) that CUVIER had found two aortic hearts, separated from each other in the *pneumodermon*, for, you will observe that CUVIER has not only described the single heart of this animal in his memoir, and given several figures of its structure, but he has even adduced the circumstance of its having a single heart, as a proof that this remarkable molluscous animal could not be allied to the cephalopods, where the muscular cavities in the sanguiferous system are more numerous.

In the class of cephalopods, the highest of the molluscous classes, the circulating system at first view appears remarkable. The auricle in the naked cephalopods, as in the conchiferous animals, is divided into two portions, each of which has precisely the same function. The two together, situate near the middle of the abdominal cavity, receive the venous blood of the whole system. They are, therefore, analogous to the right auricle of the heart of the vertebrated animals. They do not receive the blood from the respiratory organs, and, therefore, they are not analogous to the left auricle of the vertebrata. The venous blood of the system, returning by a great superior vena cava, is conveyed towards the central part of the mantle, where this great vein bifurcates, and receives two smaller lateral veins. On each side, the two portions of those veins are directed laterally to the base of the gills, where they unite, and enter two muscular cavities provided with distinct valves. In the course of this great superior venous trunk, both before and after it has bifurcated, its parietes are surrounded with glandular cellular vesicles, which open freely into their interior, and which we can inject or inflate by throwing liquid matter into the trunks of the veins, or inflating the vessels with air. Those organs which open so freely into the cavity of the four principal veins in their way to the branchial sacs or hearts, have been regarded by some as the analogues of urinary organs, destined to separate some excrementitious fluid from the blood, or as respiratory organs to aerate that fluid; while others, as Cuvier and Carus, have supposed they were rather destined to absorb something to add to the blood; and Meckel thinks they are the rudiments of a portal vein. The use of these appendices of the great venous trunks, as well as those remarkable appendices of the lateral auricles, is unknown, notwithstanding the number of conjectures to which they have given rise. The appendices of the lateral hearts have been found by Meckel to present each a small internal cavity communicating by a minute orifice with the cavity of the auricle to which it is attached. He is mistaken in stating that Cuvier has altogether overlooked these remarkable appendices in his memoir on the cephalopods, for Cuvier has accurately described them in his account of the *sepia* in that memoir. They are not found in the *loligopsus*, *octopus*, *nautilus*, though they form large appendices in the *sepia*, *loligo*, and *sepiola*. The two lateral hearts or portions of the divided auricle are differently coloured from the other muscular parts of the body, being often of a black or gray colour; they have thick fleshy parietes in the naked cephalopods, but their place is supplied in the *nautilus* by a simple round membranous enlargement on each of the branchial arteries, surrounded by the usual cellular vesicles and provided with the usual valves at the orifice of the branchial artery. The function of these two branchial auricles is to collect and propel the venous blood of the whole body through the two lateral internal respiratory organs, which are laminated and pectinated gills in the cephalopods, and there are usually valves at the origin of the branchial arteries from these auricles. The gills in the naked cephalopods are two in number, and the branchial arteries follow along their fixed or dorsal margins. In the nautilus they are four in number, two large and two small, which have four distinct branchial arteries and branchial enlargements. We thus observe that there is a slight difference in the mode of distribution of the venous blood towards those respiratory organs in the naked and testaceous cephalopods. In the *nautilus* there is a slight enlargement at the junction of the superior with the inferior cavæ. From this enlarged portion of the great systemic vein which is extended transversely towards the vesicular sacs, we observe in the *nautilus* the two trunks of the branchial arteries, on each side, which convey the blood to the respiratory organs. From those very extensive respiratory organs in all the cephalopods, the blood is conveyed by branchial veins, very wide in their middle, which run along the exterior free margins of the gills, to a great systemic muscular ventricle. We see this same structure in the *nautilus*, after the venous blood has been propelled through the innumerable capillaries of the branchial arteries spread upon those four minutely subdivided respiratory organs; it is collected here into two great venous trunks on each side, one belonging to each gill, which venous trunks occupy as usual the anterior free floating margin of the gills, and continue backwards, to enter the long transverse muscular systemic heart. The branchial veins enter this systemic heart or ventricle in different positions in different species of cephalopods.

In the sepia, in the octopus, in the loligo, the heart is nearly transverse, and they enter it towards the two ends. In the loligopsus the ventricle has a lengthened form, a fusiform shape, and a longitudinal direction, and the branchial veins enter its two sides towards its anterior broader extremity, its lengthened form being longitudinal. Most frequently, however, in the cephalopods its lengthened form is transverse, as you observe again in

the little sepiola. In the sepiola you will observe that although the ventricle is directed transversely, the branchial vein on the left side enters the extremity of the heart at that side, but the branchial vein on the right side ascends and enters the heart near the middle of its anterior margin. The great systemic arterial trunks come off, both anteriorly and posteriorly, from this great ventricle, to be sent through the whole body. This ventricle is well provided with semilunar valves, two of which are found at the entrance of each branchial vein, directed inwards, to prevent the escape of the blood into these vessels during the contraction of the heart, and two semilunar valves are seen at the commencement of the great aortal trunk, which MECKEL says CUVIER has not mentioned, although CUVIER has both described them and figured them in his plates. This aortal trunk passes upwards and backwards from the ventricle, and is continued along the middle of the back to the head, giving off numerous branches in the abdomen to the digestive organs and the muscular parts; and, forming a circle around the base of the muscular arms, it sends off a branch to each, which passes ramifying along the whole central cavity of the arm. The bulbous arteriosus is distinctly formed, both in the naked cephalopods and in the *nautilus* on the commencement of this largest arterial trunk, which comes from the systemic ventricle to supply all the anterior parts of the body. It even assumes the pyriform shape most common to that muscular and contractile part of the artery in fishes. Two other arteries are commonly given off from the systemic ventricle, one of which is distributed on the genital organs, which occupy the bottom of the abdominal sac; and the other artery, after giving some small branches to the intestine and the peritoneum, passes on to the anterior parietes of the abdominal sac, to supply its strong muscular layers. So that we find but two of the cavities of the human heart, an auricle and a ventricle, yet developed in the cephalopods, the highest of all the invertebrated forms of animals, although this auricle is again divided into two portions, to suit the lateral and distant position of the respiratory organs, as we saw before in almost all the inhabitants of bivalve shells. And in tracing upwards to the human sanguiferous system, from the lowest tribes of animals, we find bloodvessels already developed in the radiated classes, a ventricle in the articulata, an auricle added to this in the mollusca and the fishes, a second auricle developed in the amphibia and the reptiles, and a second ventricle in the crocodiles and the hot-blooded vertebrata.

CLINICAL LECTURE

ON AN

UNREDUCED DISLOCATION OF THE HIP;

On the General Changes which Unreduced Dislocated Articulating Surfaces undergo, and on the Formation of Accidental Joints.

DELIVERED AT THE JERVIS-STREET HOSPITAL, DUBLIN.

By WILLIAM WALLACE, M.D., M.R.I.A., &c. &c.,

One of the Surgeons to the Hospital; and Surgeon to the Dublin Infirmary for the Treatment of Diseases of the Skin, including Venereal Diseases.

GENTLEMEN,—We have had, in the course of the last few days,* two dislocations of the hip; one on the pubis in a female, and the other into the obturator foramen in a male. We have also had this week three dislocations of the humerus; two in males, and one in a female. But, before I enter on the consideration of these cases, I wish to call your attention to a connected view of the appearances exhibited by the dislocation of the hip which we dissected a few days ago, and which now lies before you. This will be best done by reading the notes taken at the time of dissection, and upon them I shall make some concise remarks.

As this dissection was afforded by a subject accidentally brought into my dissecting-room, nothing is known of the history of the case; but the state of the parts engaged leaves no doubt that it must have been many years since the bone had been dislocated; and from the appearance of the subject, it may be concluded that he was not less than fifty years of age.

The various objects worthy of attention in the dissection may be classed under the following heads:—

1. The external conformation of the limb.
2. The motions of which the limb appeared to be susceptible.
3. The state of the muscles of the limb.
4. The state of the vessels and nerves.
5. The state of the ligaments.
6. The state of the bones, and of the articular cartilages.

* This lecture was mislaid during the week in which it was originally designed for publication.—ED. L.

1. *External Conformation.*—The limb, which is so much inverted that the great-toe is applied to the tendo-achilles of the opposite leg, is shortened nearly four inches, and also wasted,—the thickest portion of the thigh and leg measuring each an inch and a half in circumference less than the same parts of the opposite limb. The pelvis is considerably elevated at the side corresponding to the dislocation. The cuticle of the sole of the foot is not nearly so thick as that of the same part of the opposite limb. There is a remarkable fulness about the middle of the hip, evidently produced by the head of the femur, in front of which the great trochanter lies. The centre of the head of the femur is distant,—from the anterior and superior spine of the ilium three inches and a half,—from the anterior and inferior spine two inches and a half,—from the posterior and superior spine three inches and five-eighths;—while the centre of the great trochanter is distant,—from the anterior and superior spine of the ilium four inches and five-eighths,—from the anterior and inferior spine four inches,—from the posterior and superior spine six inches,—from the posterior and inferior spine five inches and a half,—and from the tuberosity of the ischium four inches.

2. *Motions of which the Ilio-Femoral Articulation is susceptible.*—Rotation inwards is not impeded, for the state of inversion in which the limb naturally lies, may be increased. Rotation outwards is so limited that the foot cannot be everted beyond that line in which the toes are directed exactly forward. Flexion is slightly limited. Adduction is natural. Abduction very confined. Extension cannot be increased beyond the direction of a straight line—or, in other words, flexion backwards cannot be performed.

3. *State of the Muscles.*—The gluteus maximus is increased in breadth, but diminished in thickness and length. The gluteus medius is decreased in thickness; the posterior edge of this muscle runs exactly over the head of the femur. The thickness of the gluteus minimus is still more remarkably diminished. All the glutei are paler than the same muscles of the opposite limb; this also is more obviously the case in respect to the minimus, for the texture of that muscle resembles adeps rather than healthy muscular fibre. The length of the pyriformis, exterior to the pelvis, does not exceed one inch and a half. It is rounded in its form, and entirely fleshy. In place of extending to the trochanter, it is inserted, at the distance of some inches from this process, in the new capsule which covers the head of the femur. There is not a trace of the obturator internus, its place being occupied by a quantity of fat of a peculiar gristly texture. The quadratus and gemini are pale and small, and are bisected by an irregular tendinous line. The direction of these muscles, between their points of attachment, is preternaturally oblique. The psoas and iliacus internus are diminished in size, and their line of direction from the brim of the pelvis to their connexion in the lesser trochanter is so altered, that they extend from the part at which they escape from the pelvis, horizontally outwards and backwards. The triceps adductor is shortened, and such parts of this muscle as terminate in the linea aspera, lie in a direction more horizontal than natural. The pectinalis is greatly diminished in size, and its direction is very nearly horizontal. The gracilis is wasted, and the obturator externus runs obliquely upwards, from its origin to its insertion.

4. *State of the Vessels and Nerves.*—The femoral vessels and nerves having passed under Poupart's ligament, sink into a deep fossa, and extend backwards and outwards towards the lesser trochanter. They are much more convoluted or serpentine than the corresponding vessels of the opposite limb. The sciatic nerve is flattened and much curved, and appears as if it had been the seat of chronic inflammation.

5. *State of the Ligaments.*—A very strong ligamentous fasciculus extends between the anterior and lower part of the ilio pubic symphisis and the lesser trochanter. This must have performed the function of a check ligament to the motion of eversion, for every attempt at turning the limb outwards renders it very tense. A thick capsule surrounds the new articulating surface on the ilium, and also the head and neck of the femur. This capsule is connected to the edge of the new acetabulum, and, extending from this over the head of the femur, terminates by uniting with a mass of firm ligamentous cellular substance, which surrounds the neck and lesser trochanter. This capsule does not, however, form a regular cavity, for, in several places, bands cross between it and the neck of the femur; and although its inner surface is evidently smeared with synovia, it has not the smooth aspect of an original synovial membrane. There is, imbedded in the capsule, so as to form as it were a portion of it, a piece of bone of a rounded flat figure, half an inch in diameter, smooth on that surface of it which is directed towards the joint, although not covered with cartilage. It is placed exactly above the part where the femur passed out of the acetabulum at the time of dislocation, and it has the appearance of

having been a portion of the brim of that cavity detached at the time of the accident. The structure of the capsular ligament is not distinctly fibrous, but composed of a condensed cellular substance. There are no remains of the round ligament.

6. State of the Bones and Articular Cartileges.—The anterior, internal, and inferior portion of the head of the femur, or that portion which, in the natural situation of parts, is directed inwards, forwards, and downwards, is applied to the dorsum of the ilium, the trochanter major being thrown forwards. The articulating surface, which has been thus formed on the head of the femur, is flat, or very gently convex, about an inch and a half in diameter, smooth, whitish, hard, and polished, though not uniformly so; for in some parts the bone appears red and porous. The remaining portion of the head of the femur is not opposed to bone, but enclosed in and applied to the capsule of the joint. It has lost its natural smooth and rounded form, being very irregular and deprived of its cartilage. Some parts of it are covered with a substance of the nature of ligament, while on other parts there are several small pits or fossæ, but none of them appear to have been the depression for the attachment of the round ligament.

There is an irregular ossific deposit round the lesser trochanter, and also between that process and the present articulating surface. The surface on the ilium, to which the head of the femur is applied, is elevated half an inch above the level of the surrounding bone, so that this cavity appears to be formed on a plate of bone, which has been planted, as it were, on the ilium. The superior and posterior portion of the new acetabulum, or about two-thirds of its whole extent, is smooth and bony, and, being very slightly concave, is, though larger, exactly adapted to the corresponding surface on the head of the femur; but its anterior and lower portion is somewhat irregular, and made up of ligamentous prolongations, and of small osteo-cartilaginous excrescences of a cauliflower shape. These spring by small peduncles from the bottom of the outer and upper portion of the old acetabulum, and thus form a portion of the new articulating surface. The aspect or direction of the articulating surface on the ilium is backwards, outwards, and upwards. A groove is formed one inch in depth on the outer side of the ilio-pubic symphisis, for the lodgment of the conjoined tendons of the psoas and iliacus muscles, in their passage over the brim of the pelvis to the lesser trochanter. There is scarcely a vestige of the old acetabulum. In its situation there is a superficial fossa of a triangular form, filled with a fibrous substance continuous with the surrounding cellular tissue. There is no articular cartilage on any portion of the bones which form the new joint.

Remarks.—It is evident that this must have been a dislocation of the femur directly upwards on the dorsum of the ilium, accompanied by a fracture of the superior edge of the acetabulum. It may be called a partial dislocation; for a portion of the original acetabulum forms a small part of the articulating surface which at present receives the head of the femur. The shortening and inversion of the limb, the situation of the trochanter and of the head of the thigh-bone, as felt prior to dissection through the integuments and muscles, and the nature and extent of the motions of which the limb appeared to have been susceptible, constitute exactly the symptoms which occur in this form of dislocation. It is remarkable how much the pelvis was elevated on the side corresponding to the dislocation; for when we consider the situation occupied by the head of the femur, it is clear that the limb was not necessarily shortened from this cause more than one inch and a half; yet when we compare the length of the two limbs, we find that the malleoli, patella, &c. of the dislocated limb are nearly four inches above the level of the same parts of the opposite limb. So great a change in the direction of the pelvis must have been the result of time; and here it may be remarked, that it is a change contrary to that which might, *prima facie*, have been expected. For, it is natural to suppose that, as the limb must have been shortened by the dislocation, there would be an effort to depress the corresponding side of the pelvis, for the purpose of making amends for that shortening. The elevation of the pelvis on the dislocated side may, however, be accounted for in the following manner. In consequence of the obliquity of the new joint which was formed between the ilium and femur, the dislocated limb must have been unable to bear its own natural proportion of the weight of the body. The trunk was, therefore, inclined over the sound limb, to bring the centre of gravity of the superincumbent parts within the base of sustentation afforded by that limb; but this could not be done without a corresponding elevation of the pelvis on the dislocated side. In confirmation of this view of the matter, I may remark, that the state of the cuticle on the sole of the foot of the dislocated limb, clearly demonstrates that this limb had supported only a small portion of the weight of the body.

The entire or a part of the muscles of the limb which has been dislocated, frequently undergo important changes, which are well illustrated by the present dissection.

1st. When dislocated bones are allowed to remain in such a situation that the natural movements of the limb are prevented or restricted, its muscles become diminished in size, or wasted. This change had obviously taken place on almost all the muscles of this limb, as appears by comparing its measurements with those of the same parts of the opposite limb. But although there was in this case a general shrinking or wasting, this was more obvious in some of the muscles than in others, and in none more than in those whose office it was to rotate the limb outwards; a motion which, from the situation of the bones, as well as from the existence of the check ligament, we noticed had been rendered almost impossible.

2ndly. If a tendon be torn across at its junction with the fibres of a muscle, the detached ends of the muscular fibres become permanently connected or united to those parts with which they may be brought into contact. This appears to have been the case with the pyriformis.

3rdly. If the fleshy fibres of a muscle be torn through, they are after a time reunited to each other, not, however, by muscular tissue, but by tendinous fibres. So that the muscle assumes the character of a biventer or digastric. A reunion of this kind was exhibited by the gemini and quadratus femoris.

4thly. If the tissue of a muscle be so torn, displaced, and injured, as to render its re-union by tendons impracticable, the entire texture of the muscle is changed, or, rather, the muscle is absorbed, and there is deposited in its place a substance of a peculiar texture, resembling a mixture of adeps and fibro-cartilage. This appears to have been the case with the obturator internus.

5thly. When the distance between the points of attachment of a muscle is either increased or diminished, the muscular fibre undergoes such changes as may be necessary to adapt itself to its new state. Thus muscles are sometimes shortened, and sometimes elongated. The triceps and others were in this case shortened, and the quadratus and gemini elongated.

When any of the ligaments of a joint have been torn during the act of dislocation, if the bone be allowed to remain in such a situation, that the torn ligaments can no longer serve any useful purpose, they are absorbed, and completely disappear; or they are changed into cellular tissue, and become confounded with the surrounding parts. Thus, in the present case, there was not the slightest remains of the round ligament.

In all complete dislocations of enarthrodial joints, the capsular ligament is, in my opinion, necessarily ruptured; but if the bone be returned into its natural situation, the laceration is quickly repaired; whereas if the displacement be allowed to continue, a capsule is formed round the joint, partly by the original lacerated capsule, and partly by the surrounding tissues, which become converted into capsular tissue. It is more than probable that the capsule of the joint was lacerated in the dislocation before us, although this dislocation must be considered a partial one; yet there is not any appearance of laceration, for there is here a perfect, very thick capsule; but although this capsule is remarkable for its great thickness, it is not formed of those glistening fibres which we may suppose entered into the formation of the original capsule. It has the appearance of a firm condensed cellular tissue, and although its inner surface evidently possessed the power of secreting synovia, it does not exhibit the smooth, shining aspect of a synovial membrane.

Nature does not appear to have the power of forming articular cartilages in those accidental joints which result from unreduced dislocations, for the new articular surfaces are always covered by a lamina of bone, which resembles in appearance the ivory-like substance sometimes found in natural articulating surfaces, of which you may here observe great numbers of curious specimens. (The lecturer exhibited several very fine specimens of enamelled articulating surfaces.) And as a cartilaginous surface cannot easily play on a bony surface, the original cartilage which may have covered the head of the dislocated bone, becomes absorbed, and its situation is occupied by the same kind of tissue as that which forms the new surface upon which the head of the bone is applied.

In accidental joints, the result of disunited fracture, the ends of the bones appear to be covered by an articular cartilage. This substance is not, however, of the nature of the articular cartilages of original formation. It corresponds in its character with the temporary cartilage of bones; or, more properly speaking, it is bone in a state of imperfect formation.

If, in consequence of dislocation, the head of a bone be removed from a cavity naturally covered by articulating cartilage, such for example as the acetabulum, the cavity becomes contracted in size, altered in form,—in short nearly obliterated; and the cartilage which formerly covered its

surface disappears, being replaced by ligamentous fibres, growing at right angles from the surface of the bone; and these, extending outwards, become confounded with the surrounding parts. Thus, in the present case, there was scarcely a trace of the original acetabulum, except at that part where it forms a portion of the new articulating cavity, and its site was covered by a dense mass of fibrous tissue.

When it is necessary to bring a cartilaginous articulating surface to a new and higher level, and still to preserve an articulating surface, it is accomplished by the growth of excrescences connected by peduncules with the surface from which they spring. This law was remarkably exemplified in the present dissection by those excrescences which grew from the bottom of the upper part of the acetabulum, and which thus raised that portion of the old cavity to a level with the new articulating surface. These excrescences illustrate the mode of formation of the cartilaginous bodies which we occasionally find loose in joints; for it is evident that a trifling force might have detached them from the surface upon which they grew, and they would then, of course, be found loose in the interior of the joint.

Of all the textures connected with unreduced dislocations, there are none which exhibit more remarkable changes than bone. It is very interesting to observe the facility with which this apparently unyielding tissue adapts itself to all those varied states which may be required. At one time we find it so completely removed in some parts, that not a vestige remains; and on other occasions great additions are made to the original bone, to serve useful purposes. Again, without either increase or diminution of the quantity of the osseous matter, we find the bone to be, as it were, so completely new-modelled, that its new shape has scarcely any resemblance to its former figure. In the present dissection, the acetabulum was nearly taken away, a new plate of bone for the formation of an articulating surface was deposited on the ilium, and the head of the femur was completely re-modelled. These changes are brought about by the action of the absorbents or the nutritive exhalents, or by the combined action of both those systems of vessels. But respecting the alterations which bones undergo in cases of unreduced dislocations, I need not enlarge, as on this part of our subject you will find ample details in books, more particularly in the works of Sir Astley Cooper on dislocations.

I have been thus particular in taking advantage of the present opportunity, to point out some of the most remarkable proofs which can be afforded of the power possessed by our structures to adapt themselves to new circumstances; and this I have done, not merely for the purpose of enlarging your views respecting the especial subject of dislocations, but to illustrate the great resources with which our system is endowed for the reparation of injuries in general; well convinced that a clear conviction, and a constant recollection, of the existence of those resources, are of the highest importance in practical surgery.

CLINICAL OBSERVATIONS

ON

VARIOUS DISEASES,

BY

MR. WARDROP.

ON UNNATURAL SOUNDS IN THE EARS, CAUSED BY DISEASE OF THE HEART.

THERE are certain morbid states of the organ of hearing,—unnatural sounds,—which are caused by changes in the quantity and momentum of the blood within the brain; in like manner as I have remarked (page 887) that the sense of sight is affected by irregularities in the circulation of the blood within the head. These affections have not been noticed either by those authors who have treated of the various diseases of the heart, or those who have described diseases of the ear.

The unnatural sounds produced by a disturbed action of the heart, are widely different from those which are caused by a simple congestion of blood in the brain, or by diseases of the different structures which compose the organ of hearing.

Besides occasional feelings of giddiness, or "swimming in the head,"—sensations somewhat like those which precede syncope,—there is a whizzing or buzzing noise, a noise like the roaring of the sea, or boiling water, or the rattling of a carriage, sometimes perceived in both ears, but more commonly only in one. Though these sounds may vary in intensity, they never altogether subside,—at least as long as the heart's action continues disturbed; and their unceasing nature may be considered as their most remarkable character. There appears little change in the functions of the ear, as far as relates to its power of distinguishing the intensity of sounds; and, as I observed when speaking of ocular spectra, the sounds subside when the disturbed state of the circulation causing them is removed.

Case 1.—A lady, in the forty-fifth year of her age, was suddenly thrown into deep affliction, which was immediately followed by a violent palpitation of the heart. About fourteen days afterwards, the palpitations never having subsided, she felt, in the evening, a noise in one ear, which she mistook for the sound of carriages passing in the street. This noise continued, with remissions, and she sometimes perceived it in both ears. It was accompanied by a "swimming in the head," and on some occasions she was unable to balance herself and walk straight. In this state a physician prescribed the loss of twelve ounces of blood, by cupping, after which the symptoms increased. She was also bled with leeches, and put upon a low diet, without benefit. Since that period, which is nearly two years ago, she has never lost the unnatural sensation in her right ear, and though the palpitations of the heart vary in degree, they have never altogether subsided.

Case 2.—A gentleman, about forty years of age, applied to me on account of a deafness and perpetual noise in one of his ears, which he likened to the rushing of water. He had, besides, the sensation of a "swimming in the head," and for these affections he had been treated by bleedings and antiphlogistic remedies for upwards of nine years. The abdomen was full and tense, the tongue considerably furred at the root, the pulse vibratory and small, though easily compressed, and there was an increase in the impulse of the heart.

Considering the affection of the ear and head to depend on the disturbed state of the heart's actions, and on derangement of the *primæ viæ*, I commenced the treatment of this patient by freely evacuating the alimentary canal with a course of purgatives. This was followed by a dose of James's powder, continued for some nights,—afterwards administering small doses of colchicum, and, finally, using the sulphate of iron. By these means his health was progressively restored, and the circulating and digestive organs daily improved, and during this period the sensations in the head and ears were greatly mitigated, and I saw him three years afterwards enjoying a better state of health than he had done for a long time, though he still had a slight degree of deafness.

Case 3.—A public dancer consulted me on account of palpitations, of which she had complained upwards of six years, and which had been occasioned by excessive fatigue in dancing. At the same time that these commenced, she suffered greatly from dyspnœa and shortness of breath, "swimming in the head," and a sound in her right ear, which she compared with the rushing of water, which has never ceased, though varying much in degree at different times since its commencement.

Remarks.—Whatever excites the nerve of any of the organs of sense, creates such sensations as the particular nerve is ordinarily employed in conveying to the sensorium. Irritate the eyes, the nose, the tongue, or the ears, with the galvanic fluid, and you have sparks of fire, smells, tastes, or sounds, each according to the function of the organ of sense which is thus excited. Hence, changes in the circulation of the blood within the head, when influencing the nerve of the eye, cause the appearance of spectra; and changes in the distribution of the blood in the brain, influencing the nerve of hearing, produce sounds.

I have observed that these unnatural sounds are not necessarily connected with any diminution in the power of the ear to distinguish sounds of different intensities, though, at the same time, such an imperfection may also exist—as in the eye, although the spectra may, more or less, interrupt the free use and nice application of the organ of vision, yet the person may still possess the power of distinguishing the most minute objects. I am persuaded that many of those cases of deafness which are called "nervous" are caused by a disturbance in the circulation of the blood through the brain, in consequence of the heart's actions being changed—a class of cases which are usually considered to be incurable, and wherein the local means commonly resorted to cannot avail. The plan of treatment in such cases, which I have found most useful, is to disregard, entirely, all local remedies, and to endeavour to mitigate the disease of the heart.

Venous Pulsation.—In a gentleman labouring under pneumonia, attended by Mr. M. Collis and myself, the action of the heart was very powerful, and a *distinct pulsation*, corresponding with each stroke of the left ventricle, was perceptible in all the veins of the back of the hand. Mr. Crampton also witnessed this curious phenomenon. Venous pulsation was also quite evident to Dr. Ireland, Mr. Crampton, and myself, in a lady in Parliament Street, who was attacked with very acute peritonitis. These are the only instances of it in the extremities I have seen.—*Dr. Graves, in Dublin Medical Journal, Sept.*

REMARKS ON

SPURIOUS MELANOSIS OF THE LUNGS.

By WILLIAM MARSHALL, *M. D., Cambuslang, near Glasgow.*

WHEN I communicated the cases of spurious melanosis which appear in the 559th Number of this Journal, I expressed my intention of resuming the subject at some future period. This I proceed now to do, prefacing my remarks, however, with a case of the disease which I have had an opportunity of inspecting since the date of my last communication.

Case 1.—The subject of this inspection was David Shedden, æt. 57; he had been engaged in coal-mining from his youth; he was of intemperate habits, but had always enjoyed good health until about ten years ago, when, by a fall of stones in the pit, he had one of his thigh bones fractured, and was much bruised in the chest. On recovering from the effects of this accident, he returned to his employment, and although harassed by occasional attacks of cough and dyspnœa, he continued at work until March 1827, when those symptoms became so highly aggravated as to compel him to abandon the mine; but he continued to do light work above ground until the close of 1833. During this time the expectoration which accompanied his cough was muco-purulent, and such was the severity of his occasional attacks of dyspnœa, that they resembled asthma very closely. In winter his symptoms were always aggravated, and in December, 1833, he was confined to bed with an acute attack of his pectoral complaints, accompanied by fever, and ending in general anasarca, which continued for two months, but finally yielded to diuretics. He recovered from this attack, regained strength, and returned to his employment, but had not continued at work above four weeks when exposure to cold occasioned a recurrence of his complaints; dyspnœa was at this period most distressing, and the expectoration was copious, though *still* muco-purulent; anasarca again supervened; the dropsy was not now confined to the cellular membrane, but effusion took place, both into the cavity of the chest and the abdomen; and as it continued to increase, he sank under his disease, and died on the 25th of April, 1834.

Post-mortem Inspection.—On lifting the sternum, the mediastinal glands were seen to be slightly tinged with black matter. The pericardium was considerably distended, and on opening it it was found to contain above eight ounces of fluid, while the heart was much enlarged. There was copious effusion into both sides of the chest. The right lung had contracted numerous old and firm adhesions to the costal pleura. When cut into, this lung presented throughout the jet-black colour characteristic of melanotic infiltration, and the fluid in the chest was tinged as deeply as ink by the matter which oozed from the incisions, and by handling the lung, the hands were stained as if they had been dipt in a mixture of lamp-black and water. Several portions of this lung were hepatized, and sections of some of these portions displayed incipient vomicæ; the largest cavity did not, however, equal the bulk of a small nutmeg. The left lung adhered pretty generally to the costal pleura. The black infiltration was perfectly recognisable in it, but by no means in the same degree as in the right lung. Here and there commencing hepatization might be detected in its substance, but the lung was generally respirable, as it floated freely in water.

The abdomen contained several pints of fluid. The liver was enlarged, and its substance when cut into exhibited a granular and mottled appearance. The other viscera were healthy.

Remarks.—This case presented one striking feature, in which it differed from the cases formerly detailed, in so far as the expectoration did not at any period of the disease exhibit those peculiar characters which so perfectly identified the sputum in these cases. In this circumstance there is confirmation of the opinion hazarded in the former paper, that the black expectoration does not appear until the substance of the lung begins to break up, and, consequently, that its appearance indicates an advanced stage of the disease.

In all the cases formerly related, the disease had run its course, and death was fairly referrable to the extensive disorganization of the lungs. But in this case the copious effusion into the cavities had accelerated the fatal issue, and an opportunity was thus afforded of ascertaining the fact, that the secretions from the lungs may be untinged by melanotic deposit, though the entrance of those organs be deeply charged with this peculiar infiltration.

The various inspections I have now had an opportunity of witnessing, have presented four different conditions of the substance of the lung, which may be presumed to mark so many consecutive stages of the disease.

1st. The lung deeply stained with the melanotic deposit, yet soft, crepitous, and floating, yielding the black matter freely on maceration, and losing intensity of colour during that process.

2nd. A similar condition of the general substance of the lung, but, scattered through it, hepatized nodules of greater or less bulk,—these characterized by their greater resistance to the knife, their deeper jet colour, and the absence of crepitation.

3rd. These hepatized portions occupied by vomicæ in various stages of progress.

4th. General disorganization of the lung; its centre engaged by extensive and irregular excavations, traversed by shreds of induration and friable pulmonary substance; the bronchiæ semi-ossified at their roots, and terminating abruptly, and open-mouthed, in these excavations; the fluid contained in these cavities intensely inky, and the portions of remaining lung of a deep jet colour, retaining this colour in spite of repeated and continued maceration.

The diagnosis of this affection previous to the appearance of the black expectoration seems still obscure. But were a case of pulmonary affection to occur in the person of an individual attached to mines, in which spurious melanosis had appeared, and were the chest symptoms attended by the early supervention of dyspnœa, and did they become chronic in their form and duration, the existence of spurious melanosis might be suspected. On these data, but probably as much upon a certain resemblance betwixt the cases and those detailed, which, though it may strike the eye of an observer, yet cannot be conveyed in words, I have hazarded the opinion that the disease exists in two individuals at present under my care.

Different opinions have been entertained in this quarter regarding the origin of this disease. Some attribute it to the effects of blasting with gunpowder under ground, others to the inhalation of the lamp-black or soot, formed by the oil-lamps of the miners.

Whatever may be the *modus operandi* of blasting in the production of this disease, the theory can have no weight here, as in the pits in which the patients named were employed, the coal is not wrought by blasting, this process being confined to the destruction of the dikes or troubles which occasionally intersect the coal stratum, and to the operation of driving a stone-mine, or level,—departments of the work in which these men were not employed.

As to the disease originating from the inhalation of lamp-soot, it becomes those who entertain such an opinion to explain why the disease is confined to certain coal districts, and to certain pits in those districts, though, as is well known, oil-lamps are used in all the collieries throughout the kingdom, and the cause thus assumed is, consequently, in general operation.

The cases related have all occurred in two pits out of the many scattered over this district; and, further, the disease is, I believe, unknown in the Newcastle collieries, although, from the method of their ventilation,* and from the vast extent of the workings, and, consequently, the number of lamps employed, they present the most favourable circumstances for the development of the disease, were inhalation of soot its cause.

The true explanation of the origin of this disease in colliers seems to be, that it is in consequence of the inhalation of fine coal dust, and its deposition in the substance of the lung. That coal may float through the air in particles sufficiently fine to be inhaled without immediate irritation, and that it is thus inhaled, is a matter of common observation. The expectoration of colliers is tinged of a black colour for several hours after returning from work, and during the strikes, which not unfrequently occur, the black tinge of the sputum has been observed at the end of several weeks.

In the collieries in which these cases have occurred, this fine dust is carried along by the currents of air to a considerable distance from the workings, so that on descending into the pit, the body is speedily covered with a fine coating of it; it even insinuates itself under the closest parts of the dress, and even under the linen; and, further, if colliers attend work with open wounds, whether of large or small size, this powder becomes incorporated with the raw surface, without impeding the process of cicatrization, producing a mark as indelible as the Indian tattoo, or the gunpowder prickings common among sailors.

When this fine dust is inhaled, it is, in ordinary cases, gradually discharged with the expectoration, and even though a proportion of it should be absorbed, we may suppose that if the lung be healthy, it may either remain innocuous, or be thrown off through time. But if the bronchial and vesicular surfaces, or the substance of the lung, be diseased, and if under those circumstances an individual be daily exposed to the inhalation of this matter, it may be supposed that no such salutary efforts will take place. On the other hand, the powder may be allowed to

* Some of the Newcastle collieries have thirty miles of air course ventilated by a single shaft.

collect in the pulmonary vesicles, it may incorporate itself with the substance of the lung, its presence, as a source of irritation, may react upon the existing disease; the respiratory functions will thus become embarrassed, and those organic changes in the substance of the lung ensue, which, after an uncertain period, unfit this organ for its purposes in the animal economy.

That some such predisposition as is here presumed is necessary to the accession of the disease, is proved by its rareness; and as disease of the lungs is comparatively unfrequent among colliers, the rareness of the affection (if the predisposition consists in such disease) stands still further accounted for. Certainly, in the cases detailed, confessedly difficult though it be in such a matter as the present to distinguish betwixt cause and effect, the impression on my mind is, that pulmonary disease, arising from natural and cognizable causes, preceded in every instance the accession of the peculiar affection under consideration.

It may be said that the same objection as was valid against the inhalation of lamp-sooot, as the cause of this disease, may be urged against the inhalation of coal-dust. But it ought to be recollected, that while the former of these causes is identical in its nature in all cases, the existence at all of the latter depends upon a variety of circumstances, as the nature of the coal, the method of working it, &c. Thus, when the coal is very soft, and wrought small, as in the English collieries, or when the workings are of a wet or damp nature, from the neighbourhood of springs, or from constant leakage, the production of this fine powder can scarcely take place. But when, as in the pits in which these cases occurred, the workings are perfectly dry, when the coal, as in them, is close, hard, and compact in its fracture, and when it is wrought large by the continued and laborious application of the pick, then we have circumstances in all respects favourable to the production of this fine dust.

Were it necessary to advocate still further the opinion here advanced, respecting the origin of this disease, the collateral evidence of the analysis of the melanotic matter in Dr. Gregory's case might be adduced, as well as the direct proof afforded by the fact, that the disease only occurs in colliers, and in artificers who, like them, are exposed to the inhalation of carbonaceous matter; thus a case lately occurred in this vicinity, in the person of a workman employed in dusting moulds for fine castings with finely powdered charcoal. Finally, analysis of the sputum of two of the cases detailed, demonstrated, clearly, the carbonaceous nature of the deposit, and its unlikeness to any of the secretions, or to any animal substance whatever.

The process pursued in this analysis was the subjecting the matter to the action of nitric acid at the boiling point, subsequently to that of a solution of caustic potass, and, finally, to the operation of heat; and though the analysis was not carried so far as to ascertain the identity of the matter with coal, yet its affinity to charcoal was sufficiently evident.

Cambuslang, Sept. 12th, 1834.

HYDROPHOBIA

FOLLOWING THE BITE OF A DOG NOT SUPPOSED TO BE MAD.

To the Editor of THE LANCET.

SIR,—The very peculiar manner in which the following case of hydrophobia was excited, renders it, in a professional point of view, one of considerable interest. Being thus impressed, I feel it a duty to communicate it to you for insertion in your excellent journal.

I am Sir,
Your obedient servant,
E. L. KNOWLES, Surgeon.

Soham, Cambridgeshire,
Sept. 5th, 1834.

Case.—Wm. Hills, of Soham, ætat. seven. His mother states, that about five months ago he was bitten by a dog which was exasperated by the continued teazing of this and other boys. His shoulder was much lacerated, but the wound was considered of little importance, the animal being well and still in existence. It was simply dressed, and it soon healed; from which period, till Saturday, June the 9th, the boy appeared to be perfectly well; he then complained of thirst, nausea, and a disinclination to move. On Sunday his symptoms had much increased, and he expressed very great aversion to being washed, according to usual custom. Notwithstanding these symptoms, his friends were still impressed with the idea of the disorder being a bilious attack, until Monday, at four p.m., when the symptoms became so augmented as to induce them to apply for medical assistance.

On entering the room, the first symptom that caught the eye was the great distress depicted in the patient's countenance. The eyelids were opened to their fullest extent, accompanied by considera-

ble dilatation of the pupils; the face, neck, and chest, were bathed in perspiration; the angles of the mouth were drawn up by the spasmodic action of the zygomatic muscles, producing a horrid grin, and he was incessantly spitting a frothy mucus. When spoken to, he answered in a hurried manner, and in broken accents. There was no pain in the site of the wound, but considerable uneasiness was experienced in the region of the heart. Pulse 90, feeble, irregular, and intermitting; respiration hurried, and deglutition appeared to be entirely suspended. Notwithstanding he had great thirst, the sight of the smallest quantity of water produced the most violent spasms and jactitations of the whole body. The muscles of the back were violently contracted, and the arched appearance existed which is so frequently observed in tetanus, with which disease it might have been confounded had it not been for the effects which the appearance of fluids produced, and the absence of a recent wound. The spasms occurred, when not excited, about every five minutes.

At six p.m. On visiting him at this period, I found him in every respect the same, with the exception of having a great antipathy to his bed; he was therefore allowed to dress and walk during the intervals of the paroxysm. We now succeeded, by means of a small reward, in prevailing upon him to swallow a strong opiate. He made repeated attempts ere he could accomplish it; and although it was succeeded every time by a violent spasmodic constriction, yet, so determined was his character, that he persisted to the last degree in his efforts. The warm-bath and an opiate enema were now proposed, in the hope of alleviating the spasmodic action; but we were obliged to abandon it, in consequence of the powerful and distressing effect produced on the patient's mind. The avidity with which he took an orange was astonishing; violent spasms however instantly succeeded, particularly about the throat and adjacent parts. He appeared perfectly sensible, and repeatedly expressed his thanks for the small reward given for trying his utmost to overcome the difficulty that arose in swallowing. Great anxiety still prevailed in his countenance, with sighing, and every word was succeeded by a convulsive sob. The draught was ordered to be repeated every hour.

Ten p.m. The malady is evidently advancing, although the spasms continue much the same. Symptoms of exhaustion are now evident. His friends are unable to confine him in bed, except by the assistance of two men. He is constantly spitting, and has a great propensity to bite his attendants, who cannot now prevail upon him, either by threats or reward, to suffer the smallest quantity of fluid to pass his lips. From this time he gradually became worse, and at 12 p.m. death put a period to his extreme agony.

Remarks.—I am sorry to say that no post-mortem examination was permitted. There is, in my opinion, in this case, a character well worthy the attention of the profession generally, as it may unfold the answer to a question which has long been doubted by the medical world, viz. whether the canine race are capable of communicating *hydrophobia* under a state of irritation or excitement, when not actually labouring under the disease. In Dr. Thomas's *Practice of Physic*, the following remark is noted:—M. Rossi, in the *Mém. de l'Académie de Turin*, tom. vi., endeavours to demonstrate, by cases, that animals, previously healthy, when enraged or irritated, in a high degree, are capable of communicating the disease by their bite, although Dr. T. considers that sufficient evidence has not yet been advanced to establish the principle satisfactorily. I made every inquiry, both of the patient and, since his death, of his mother, as to whether he was bitten by any other dog, and they positively answered in the negative. What led me to the investigation in a more minute degree than I otherwise should have pursued it, was the fact that the animal which inflicted the wound continues alive and well up to the present time. Therefore the facts of this case are in perfect unison with the sentiments of the French author: and as practical knowledge is of more value than theoretical speculation, I shall not trespass upon the valuable time of your numerous readers, by advancing any physiological hypotheses on the subject.*

EMPLOYMENT OF

FREE INCISIONS IN GLOSSITIS.

To the Editor of The Lancet.

Sir,—In a communication in The Lancet (page 634) from Mr. Horne on the efficacy of the nitrate of silver in glossitis, there is a case related in which the nitrate was applied every morning for the space of a fortnight, and in the early stage of the disease twice a day. A fortnight is a long time to con-

* An opinion on this subject expressed by Sir B. Brodie, is recorded at page 944 of the present No.

tinue a painful remedy in a disease so dangerous as generally to require instant relief, and which may be obtained with very little and only momentary increase of the patient's sufferings.

The nitrate of silver may be very useful in mild cases, and, probably, in cases similar to the one related, when the patient is much reduced, and cannot afford to lose blood; but I am sure, from what I have seen of the disease, that, when very severe, deep incisions, extending from the base to the tip of the tongue, are more successful than any other treatment. It is equally certain that mere scarifications, and the local application of leeches in alarming cases, do harm. "The swelling and suffering will often be found to be increased dreadfully after the oozing of the blood has ceased." This was well observed in a case that occurred in Mr. Webster's practice at St. Alban's, last year, when I was his assistant, in which, had not the most energetic treatment been adopted, the patient must have died from suffocation.

The Case.—A gentleman, 80 years of age, arose in the morning in his usual good health, and went into his farm-yard, where, having detected something wrong in the conduct of his servant, he was exceedingly enraged, and scolded him furiously; when he returned into the house his wife remarked that he did not speak so distinctly as he was accustomed to do; this he did not notice much himself, but in a short time, and during his breakfast, he was unable to move his tongue without pain, and very soon afterwards it enlarged so much as to fill his mouth entirely, preventing deglutition and affecting respiration. At this time, 9 o'clock a.m., Mr. Webster was sent for, and having been informed by the messenger of the nature of the case, he took with him leeches and appropriate medicine. I saw the patient an hour afterwards; he was in a very dreadful condition, the tongue was enormously swollen, and protruded from the mouth, and the skin forming the under part of the chin was much distended and discoloured, apparently from effused blood, some vessel probably having yielded during the paroxysm of rage, thus rendering him a horrid spectacle. The tongue was freely scarified, and leeches were applied to it, without affording the smallest relief. On the contrary, the swelling and suffering were much increased. About noon the patient breathed with so much difficulty that it was deemed necessary to have the opinion of another surgeon, as unless he was immediately relieved suffocation would quickly ensue. It was accordingly determined that deep and extensive incisions should be made into the tongue, as the only chance of saving life, and Mr. Webster made use of a common scalpel to effect that object, cutting through half the substance of the swelling, from end to end, in several places. The hemorrhage was profuse, and the result of the operation most gratifying. The tongue was instantly reduced so much that it could be returned into the mouth, the breathing became natural, and the pain was greatly diminished. The patient, in fact, from a state of extreme danger was restored to comparative comfort. In the evening leeches were applied to the sides and under surface of the tongue, and saline aperients were administered during the night. The following morning the tongue was reduced to almost its natural size, and the patient could articulate without difficulty, and could take any kind of fluid food with comfort. In less than a week from the day of attack he was perfectly well, slight debility only remaining.

Had the nitrate of silver been trusted to in this case, I fear the consequences would not have been so favourable, for had the active measures that were adopted been delayed one hour longer, the opportunity of doing good would have been for ever lost. Death would have terminated the patient's sufferings before that time had elapsed. The superiority of this treatment over that with the nitrate of silver is very apparent, for the tongue recovers its use in two days, whereas by using the latter it does not resume its healthy condition until fourteen days have expired. Even in cases where there is great debility and exhaustion, I would prefer a good topical bleeding, by incision, to the nitrate of silver, as the strength is generally soon regained, but I would not bleed from the arm.

I remain, Sir,
Your most obedient servant,
G. M. Todd, Surgeon.

Old Kent Road, Sept. 1, 1834.

MALIGNANT CHOLERA.

SMALL AND FREQUENT DOSES OF CALOMEL.

To the Editor of The Lancet.

Sir,—As the Asiatic cholera has again shown itself in this kingdom, I wish to be allowed a few words with the public, to whom, from your Number of Saturday, I am glad to perceive they will be as acceptable, as, from your invitations to correspondents on this subject, I hope they will

be to you. Trusting you will find room for this communication, I remain, dear Sir, your very obedient servant,

J. Peacock, M.D.

Darlington, Sept. 11th, 1834.

It was on the 1st of October, 1832, that I made known, through the medium of the *London Medical and Physical Journal*, an easy and expeditious mode (which subsequent experience has confirmed) of curing the Asiatic cholera by small and repeated doses of calomel washed down by a little fresh cold water. So far as I have either read or heard, I was the first who recommended this very simple and most efficacious remedy. In the following year I sent to the same journal some further particulars of a mode of treatment with which I was anxious to make the profession acquainted; but it seems that about this time that journal was discontinued, and my letter was handed to the editor of the *Medical Quarterly Review*. I have just seen the number of that periodical for January last, in which I observe the editor has inserted a very short and garbled extract from my letter, and most unfairly* added, that "this will remind our readers of Dr. Ayre's system, who gives a grain of calomel every five minutes, but combines it with a drop of opium." Now, if there was any reminding in the case (as there is not), I should observe, that I had publicly recommended *calomel alone*, before Dr. Ayre had published *any* practice of his.

But far more than I am interested in the question of who first proposed small doses of calomel in this disease (though no one is indifferent to the reputation of having made a useful discovery), am I desirous that my treatment of Asiatic cholera should not be confounded with Dr. Ayre's plan, to which it bears no resemblance. Mandon and Monmouth both begin with *M*, it is true, but the words are not more dissimilar than my mode of meeting cholera is from the method of Dr. Ayre, which, besides being *commonly* single-grain doses of calomel, generally given every five minutes, included laudanum, brandy, rice clysters, mustard cataplasms, bags of warm sand, &c.*

It is no part of this letter to discuss the merits of these auxiliaries, my only object is to state the plan which I have invariably (and invariably successfully) adopted, and which consisted simply and wholly of grain doses of calomel every ten minutes, washed down with cold water. Upon my first acquaintance, indeed, with the Indian cholera, a small matter of rochelle salt was put in the water, but when I became familiar with the disease, I found I could trust safely to the grain of calomel every ten minutes without anything else. Out of upwards of thirty cases of Asiatic cholera, which I have treated in this way, *I have not lost one patient.*

So soon as the plan which I have recommended, and which (so far as the experience of a man of forty years' extensive practice justifies me in speaking strongly), I pronounce to be *infallible*, has been prosecuted for four or five hours, there is generally felt a little warmth or moisture upon the limbs, and the pulse becomes sensible to the touch; and after two or three black stools, the evacuations regain their natural colour and odour. If two or three of the physicians and surgeons to public dispensaries (than whom no men have been more distinguished for science and usefulness) would condescend to try the effect of this remedy in Asiatic cholera, I should not doubt, from what I have seen of it in many blue cases as severe as the one I am about to relate, of their giving a favourable report of its operation.

Case.—A lady, after having been terribly harassed by a long journey, in which she had not gone to bed during several days, was attacked with this complaint in a very severe manner. Immediate assistance was not at hand, and the colourless diarrhœa and vomiting had advanced to a very high pitch when we were called in. The muscles of her legs and arms were rigid and very painful; her eyes and every feature were frightfully sunk; her tongue and her limbs were cold as icicles; the skin upon her face as well as her hands and feet was of a black blue, and when she attempted to speak, it was done with the piping difficulty of a very old person in the act of death; her stomach rejected her calomel pill several times, but not a minute was lost in its re-administration. She kept throwing her arms from side to side, and moaning most piteously, and the beholders begged that she might not be any longer teazed with medicine, as the case was hopeless. We stuck to her nevertheless, and took care that she never missed her pill and cold water, which appeared to be grateful. After six hours' struggle in this way, we could plainly perceive a pulsation at the wrist. The retching had much abated after the medicine had been taken two hours, but after eight hours black purulent matter was discharged by stool, and the blue tint upon her face and limbs had

* We cannot think that the misrepresentation or personal offence indicated by the charge of unfairness, was designed by our contemporary.—Ed. L.

† The communication of Dr. Ayre in the last Lancet had not been read by Dr. Peacock when this letter was written.—Ed. L.

diminished much, and although her tongue and breath still continued very cold, her limbs were improving both in rotundity, warmth, and colour. At the tenth hour, although still suffering under dreadful debility, we assured her friends that she was safe.

THE LANCET.

London, Saturday, Sept. 20, 1834.

THE resignation by JOHN WHITSED of the office of Physician in the Aldersgate-street Dispensary, is an event that cannot astonish more than a very few members of the profession. When the anti-medical committee insulted the medical practitioners of the metropolis last year, that body had the folly to believe that men of character and ability, having fixed principles of integrity to govern their conduct, would come forward as candidates for those offices which had been so honourably relinquished by Drs. BIRKBECK and CLUTTERBUCK, and their spirited colleagues. At first no candidate at all could be obtained, and a considerable period elapsed before two individuals, connected by legal ties with the profession, could be prevailed upon to make an announcement which implied that they prized not medical honour, regarded not the respectability of the profession, and valued not the good opinion of their medical brethren. No sooner, however, had WHITSED, YATES, CARSWELL, and WYATT, become candidates for the cast-off offices in the Dispensary, than the anti-medical Committee, rejoicing in the success of their conspiracy, considered that their triumph in iniquity was achieved, and the degradation of the profession rendered at once both complete and final. The attack on the rights of the profession was of too malignant a character to be witnessed without exciting an intense feeling of indignation in all ranks of the faculty throughout the country. Meetings were everywhere convened, and resolutions were as generally adopted, denouncing, in the strongest possible terms, the conduct of those physicians and surgeons who had consented to become the tools and slaves of a Committee which had dared to attack, not only the legal privileges of the profession, but even to impugn that moral reputation on which the successful application of the principles of medical science must ever depend with such a nation as the English. If the public feel no confidence in the integrity of a physician, aid will not be solicited from the talents of that physician, because no security can be felt that his talents will be justly directed. In showing their abhorrence, then, of the outrageous proceedings of the anti-medical Committee of the general Dispensary, the medical body furnished the best evidence of their detestation of everything that was mean and dishonourable that could be practised by men who profess to be guided in their movements by the fair hand of Charity. In denouncing the desertion of WHITSED and Co., the respectability of the profession was vindicated. In treating with contempt and scorn the offers of the anti-medical Committee, the utility of the profession, founded on its integrity, was effectually secured to the public. If WHITSED and his associates had the folly to believe that they could act in opposition to the mass of their professional brethren, we apprehend that some of them have paid dearly for their folly. Did they imagine that the half-dozen intriguing charity-mongers who fawned upon and flattered them, could furnish them with that support in practice which men of respectability and talent have a well-founded reason for considering they should ever receive from the members of an enlightened community? Whatever may have been the designs of the anti-medical Committee and their tools, it was

quite evident that there could be no harmony of action amongst them, arising from a feeling of mutual confidence.

The upholding principle of self-respect was wanting; hence must have been quickly produced a reciprocal distrust of each other's deeds. Of course it will be denied that there has been any loss of confidence between the Committee and their official victims,—that there has been any wrangling, any indication of discontent, or any sign of the workings of that canker-worm, self-reproach. Whatever may be the declarations of the Committee-people and their tools on these points they will avail but little while we have such circumstances to influence our decision as the sudden unexplained resignation of Dr. JOHN WHITSED. That the cause of the resignation is concealed from public view will be acknowledged on a perusal of the letter of Dr. WHITSED, and the advertisement put forth by the anti-medical Committee. It is necessary, however, that we should notice the dates of those documents. WHITSED'S letter is written September 4th, the advertisement is dated September 6th. Now the letter, be it remarked, is one in which the resignation of the office of physician is announced to the Governors. Only *one* day elapses, and out comes this advertisement, dated Sept. 6th:—

"*General Dispensary, Aldersgate Street.*—An Extraordinary General Meeting of the Governors of this Institution will be held at the Dispensary House, in Aldersgate Street, on Tuesday, the 30th day of September instant, at 10 o'clock in the forenoon precisely, for the Election of a Physician, in the room of Dr. John Whitsed, resigned. Such election (if contested) will be by ballot, to commence at 10 o'clock in the forenoon, and close at 3 o'clock in the afternoon precisely. Gentlemen offering themselves as candidates are to attend the Medical Sub-committee of this Institution, with their testimonials of qualification, on Tuesday, the 23rd of September inst. at 1 o'clock in the afternoon precisely, at the Dispensary House.

"By order of the General Committee,

"JOHN WOOD, Hon. Sec."

We are unacquainted with the by-laws of the Dispensary, but it certainly appears most extraordinary that a day should be named for electing a physician in little more than four-and-twenty hours after the resignation of one of the medical officers had been announced. Whence the necessity for such precipitancy? Can the body of the Governors regard such treatment as respectful? No communication of the resignation of WHITSED is forwarded to the majority of Governors, no *general meeting* of the "life" and "annual subscribers" is called for the purpose of considering and accepting the Doctor's resignation, but the members of the anti-medical Committee take upon themselves the management of the entire business. WHITSED sends in his letter on the 4th of the month, and on the 6th it is advertised by the Committee to the world that in exactly three weeks and three days from the date of their announcement a physician will be balloted for at the house of the Dispensary, on which occasion an extraordinary general meeting is to assemble; thus until the Committee have so arranged matters that the Governors will be compelled to act in obedience to their wishes, they are not called upon to assemble or share in the proceedings,—they are to meet for the purpose of *balloting*, and for nothing more,—they are to enter into no discussion at the Dispensary, nor share in the deliberations of the all-sufficient anti-medicals. When the Governors meet, they will be informed by the Treasurer that the ballot having been appointed to commence at 10 o'clock, it must be proceeded with at that hour, otherwise the election will be void. The forces of the anti-medicals will be brought forward on this occasion, as on the last, and thus another supple being, sponge-like, will be forced into the dirty office, open for his reception by the resignation or the rejection of WHITSED. That the persons who

now subscribe to the Dispensary will submit to this treatment, we can readily believe; in truth, from what we have observed of their past conduct, we know not the insult that could be offered to them by the anti-medical Committee which they would be induced to resent. Meekness of spirit becomes those minds which are devoted to purposes of charity.

It is of little importance whether WHITSED be disgusted with the Committee, or whether the anti-medicals find their man ill-calculated for the accomplishment of their designs. Enough will be shown, if the circumstances at our command establish the fact that the retired officer has not published a satisfactory account of his resignation. From WHITSED'S obscurity or ambiguity of statement, and from the precipitate manner in which the Dispensary Committee have acted in receiving letters of resignation, and instantly appointing a day for *balloting* for another physician, the profession will not fail to draw just inferences. Let us then examine the letter of resignation.

"*To the Governors of the General Dispensary, Aldersgate Street.*

"My Lords, Ladies, and Gentlemen,—As I expect, ere long, to reside at a greater distance from your dispensary, and as I perceive, from the increasing prosperity of the institution, that my duties as physician will, in consequence, be greater than the state of my health will allow me fully to discharge, I find myself compelled, most reluctantly, to resign my appointment. Nevertheless I cannot separate myself from an institution, the blessings of which are so widely diffused, without considerable regret; regret though unfeigned, yet associated with the hope that my successor will be free from bodily infirmity, and therefore enabled to perform his task not only with more ease than myself, but with more real and solid advantage to the charity.

"Allow me to thank you, individually and collectively, for the kind attentions I have invariably received, and believe me to be, your faithful and obliged servant,

"J. WHITSED.

"Southampton Row, Russell Square, Sept. 4."

A more curious document was never penned. Can any man discover in it an explanation of the real cause of his resignation? He "expects," good man, ere long, to reside at a greater distance from the dispensary;—"he expects, ere long." Does he not know *where* he is going to reside? Is he about to be wafted through the air in a balloon, and to gratify with his presence the inhabitants of some distant town, who are at present unconscious of the great blessing Providence has in store for them? Pray, where did this strange gentleman reside when he engaged to execute the duties of his late office? In "Southampton Row," Russell Square, a distance sufficiently great, considering that the dispensary is in Aldersgate Street in the city. Truly, no *greater* distance could be rendered necessary. But why does the man run away from the dispensary, if he love it so devoutly? Why does he not "expect," ere long, to reside at a *smaller* distance from his admired institution? Has he aught but his own inclination to consult, or will not the anti-medicals retain him in his office? But the expectation, ere long, to reside at a greater distance, is not the only assigned cause of his resignation. He remarks, "I perceive, from the *in-*"*creasing prosperity* of the institution, "that my duties as physician will be "greater than the state of my health will "enable me fully to discharge." Softly, Doctor. How do you know that the *increasing* prosperity of the institution will be greater than the state of your health can sustain? And pray what do you mean when you apply the term of *prosperity* to the business of the dispensary? Have you aught for sale in your establishment? Do you dispose of the blood of your patients to the sugar bakers, and do you sell their bones for manure? So the *prosperity* of the dispensary is shown in the increasing num-

ber of suffering applicants for relief! As the victims of misery accumulate at the portico, so find you a multiplication of sources for congratulating yourself and colleagues on the "prosperity" of the establishment. A mind endowed with a just conception of the purposes of a dispensary would have turned with aversion from the adoption of such an epithet; but WHITSED sees in the "prosperity" of a dispensary a reason for apprehending that he will not be enabled to discharge the duties of the office of physician; whereas, in point of fact, the increasing prosperity of a dispensary would daily bring to the physician a diminished amount of professional labour and anxiety. The real prosperity of the dispensary would be shown by an increase of funds, and the decrease of the number of applicants for relief; but WHITSED seems to be of opinion that the prosperity of a dispensary can only be displayed by the exhibition, at the doors of the establishment, of hundreds of sufferers applying for relief. "Nevertheless," says he, "I can-"not separate myself from the institution "without considerable regret." *Nevertheless!* What the deuce does the man mean? *Nevertheless* is he not delighted? Is not the institution most prosperous, and does he not ere long expect to reside at a greater distance? Ah! we are obliged to him for that word in such a place. "Nevertheless" expresses precisely the opposite of what the Doctor intended; the word, for example,—to show how perversely, how ridiculously, it was employed,—might have been used as follows: "You precious anti-medicals, what an "ass I made of myself when I consented "to become your tool! Ever since I have "been here you have treated me as a "servant rather than a physician. You "have insulted me, and conducted your-"selves towards me with such marked "disrespect, that I find I am compelled "to resign. *Nevertheless* I sever myself "from the institution with considerable "regret." Introduced in this sense, the employment of the word would have been perfectly justifiable; but, curious enough, the Doctor's regret, though unfeigned, is associated with the hope that his successor will be free from bodily infirmity. Had it been feigned, the pretext, then, would have been necessarily allied with a hope favourable to the health of his successor; but *now*, as the Doctor is evidently a man of just conceptions and very benevolent feelings, his "regret, though unfeigned," is associated with the hope that his successor, by not having all the joints of his lower extremities anchylosed, will be enabled with ease to himself to discharge the duties of his office.

But we have not yet seen the conclusion of this curious farce. We learn by an advertisement in the *Times*, that a quarterly general meeting of the governors was held on the 10th instant,—six days subsequent to WHITSED's resignation, and four days after the time for the election of another physician had been appointed. As usual, the dispensary treasurer and druggist was in the chair, and as it was a quarterly meeting, we may easily imagine that the drug-treasurer was surrounded by the regular hacks of the "charity." What happened? Of course this delectable body voted WHITSED their cordial thanks for his humane treatment of the patients, for his attention to the patients, and for his zealous exertions to promote the welfare of the charity. This is pretty well when it is remembered that WHITSED has only been in the establishment about one year, and that he told the Governors on the 4th inst. that he could not satisfactorily discharge his duties, on account of his bodily infirmities. But the best part of the joke will be found in the following resolution, that "Dr. JOHN "WHITSED be appointed consulting physi-

"cian to the Institution." And who is this consulting physician, appointed by a quarterly meeting of the Governors? Why he is the person who has announced to the *whole* of the Governors, that his reasons for resigning the office of physician are, that he expects ere long to reside at a greater distance from the Dispensary, but without knowing where, it seems, and that he perceives, from the increasing prosperity of the Institution, that the state of his health will not admit of his attending to his duties!

And this is to be the consulting physician of the general Dispensary in Aldersgate-street! Are the subscribers idiots, that they tolerate such proceedings?

If it be really true that the quantity of disease has increased, and thus thrown additional labour on the physicians, that circumstance may admit of explanation, possibly, by assuming, that if none of the patients are cured, every new case becomes a permanent addition to the stock of disease already in hand, and this is what WHITSED, we suppose, would designate a most glorious state of increasing prosperity.

Whatever may have been the real cause of WHITSED's resignation, we look on this event as conveying a most useful lesson to the junior members of the profession. From what we have already stated it is obvious that much more of the real cause of the resignation has been concealed than is explained; accordingly the public will be justified in coming to the conclusion, that WHITSED is a disappointed man, and that he has not reaped those benefits which he expected to derive from associating himself with the avowed enemies and calumniators of the profession.

INSTRUMENT FOR MEASURING THE PULSE.—At the meeting of the French Academy of Sciences on the 1st inst, M. MAGENDIE read a report on an instrument invented by a Dr. HERISSON, called the "sphygmometer," and intended to measure the state of the pulse. As we intend in an early number to give a description of this useful invention, from the pen of its author, we shall merely say at present that the sphygmometer is composed of a small tube, containing a certain quantity of mercury, as in a thermometer, closed at the bottom by a portion of fine membrane (*a baudrouche*), and graduated to 80 degrees. Its application, like the construction, is excessively simple. The bottom of the instrument is placed over the radial artery, each pulsation of which elevates the mercury, and thus discloses to the eye the minutest variations of the circulation. It is unnecessary to dwell on the importance of a discovery (if such it may be termed) by which the indications of the pulse are not only subjected to the vision, but are measured with the utmost exactitude, and may be so recorded for the information of others. In this respect the sphygmometer has an infinite advantage over the stethoscope, the only instrument parallel to it in object and character.

OPERATION SAW.—We have had an opportunity, also, of examining another ingenious instrument, invented by M. HEYNE, a German physician, who has been exhibiting its utility in the Parisian hospitals. It is a chain-saw, which is worked by two wheels and a handle. The saw revolves round the point of a machine, containing the works, and resembles in form a butcher's knife. This is fixed by a sharp point, on the bow, the handle is turned, and the chain-saw revolves, while the knife approaches the operator. The bones are divided literally as if the operator were cutting the flesh with a scalpel. Not the slightest shock or disturbance is experienced in the instrument during its action.

THINGS are come to a pretty pass when ANTHONY WHITE, *President* of the Royal College of Surgeons in London, gives a VENISON FEAST to celebrate the triumph of *his* intrigues over the intrigues of GEORGE JAMES GUTHRIE, *ex-president* of the same reputable College. To this pass,

however, have events come, and a glorious day is it for medical reformers to see. Yes. A venison feast has, actually, been held at the house of ANTHONY WHITE, once surgeon of *Westminster Hospital*, specially supported by the ANTHONY the knight, another surgeon of the institution, and by Mr. LYNN, consulting-surgeon of the hospital, to commemorate the victory obtained over Mr. GUTHRIE,—a brother officer in the same establishment—in the late decision on the proposed name of the association, entitled (despite that decision) the "Westminster Hospital School of Medicine!" As LAVENDER TOM says to DROPPER,—"This comes of your vulgar avarice." Mr. GUTHRIE thought to make too much of the hospital, and to share the proceeds among a more manageable party than Messrs. WHITE and Company. The secrets of these jobs are not very readily reached, but the history of the battle, were it known, would very likely put us in mind of the following scene in *Beau Nash*:—

"DROPPER. I am going to pick the old woman's pocket.*

"TOM. Barbarian! Vandal! Rob the fair?

"DROPPER (*showing purse*). See; twenty guineas.

"TOM. Pillage lovely woman! But as it is done, halves!

"DROPPER. Halves? Is that like Pompey and Julius Cæsar?†

"TOM. Certainly; quite their philosophy. (*Aside.*) You know Cæsar *ought* to go halves. You'd have tricked me, brother. We will be even yet, and may then hang good friends again."

With regard to the hanging, we can hazard no guess; but as to the friendship, all that is past.

Thus stand matters at the Westminster Hospital, though, by-the-by, we should like to know how much "clinical instruc-" tion will be given at the hospital, by the "surgeons,—Sir A. Carlisle, Mr. White, "Mr. Guthrie, and Mr. W. B. Lynn,"‡ to the pupils of such a cat-and-dog staff as this. And thus also do matters stand at the College of Surgeons. The ex-President, the President, the President in futuro,—officers so venerable in dignity at one time, that to think they could do wrong was "treason"—consider each other to be as finished jobbers as ever even THE LANCET wrote them down. The sun casts shadows as he sets in nature, and so the sun of the system of hospital intrigue, as it nears the horizon, throws forward events as shadows on the arena of the medical world:—

We have shadows of "coming events" in nearly every hospital and public medical institution in London. At the *Westminster*, WHITE casts his shade across the path of GUTHRIE. At *St. George's*, the shadows of WILSON and WALKER darken the prospects of SEYMOUR and BRODIE. At *St. Bartholomew's*, the treasurer has publicly promised that a thorough investigation into the neglected accounts of the hospital shall forthwith be commenced At *Guy's*, King HARRISON formally tells his lecturers that the Parliamentary Committee will be "upon them," if they reform not in their attention to the students. At *St. Thomas's*, Mr. GREEN is at open war with the treasurer, and Dr. ELLIOTSON has bid adieu to its walls in a like spirit. At the *London Hospital*, Mr. TOOKE, a governor, is trying his strength with the party of Sir WILLIAM, an officer. At the *Middlesex*—no; nothing at the Middlesex is substantial enough even to cast a shadow. In Lincoln's-Inn Fields, the shadow of the new President perplexes the soul of his predecessor. In Pall Mall East the shadows of the Licentiates darken every stone beneath the portico. In Bridge Street, Blackfriars—here figurative language drops—the company have *not appointed a successor* to the office lately filled by the unfortunate EDMUND BACOT.

Affairs are, truly, in a promising condition amongst the medical conservatives.

THE EDINBURGH INSPECTOR OF ANATOMY.

(*From our Edinburgh Correspondent.*)

A PETITION has been sent up to the Home Office by our Association of Lecturers on Anatomy and Surgery, praying that Dr. CRAIGIE's appointment as *Inspector of Anatomy* may be rescinded. From the very unsatisfactory manner in which Dr. C. has

* *Leys* pupils,
† Pres. and Ex-Pres.
‡ Extract from the prospectus of the new school.

fulfilled the duties of that office, he has brought on himself the opprobrium of all the anatomical teachers. It is said that he has shown great partiality in the distribution of subjects, and has even presumed to dictate to the professors the mode in which they are to *teach Anatomy*. The conduct of this learned doctor is the more vexatious and irritating from the circumstance that he himself completely failed as a teacher of anatomy. Such indeed is the feeling which his conduct has created, that when he makes his appearance at any of the anatomical theatres to pay one of his *official* visits, he is received with noises not of the most complimentary description.

We entertain every hope that this election job of Lord MELBOURNE, which is just as much to be found fault with as his choice of a Professor of Midwifery at the University of Glasgow, will meet with due consideration from Lord DUNCANNON, who will find, if he will stoop to the inquiry, that however renowned CRAIGIE may have been in the early part of his history for cutting up "soles," he is perfectly incapable of conducting dissections of the *body*.

The Medical Faculty of the University of St. Andrew's continue to be in great spirits, and have talked big ever since the "successful" appearance of their deputies in the Parliamentary Committee room, the demand for their degrees having certainly very much increased.

Cases of Tic Douloureux, and other Forms of Neuralgia. By JOHN SCOTT, Surgeon to the London Hospital, &c. &c. London, Longman and Co., 1834. 8vo. pp. 52.

WHEN a hospital surgeon "goes to press," the most striking feature in the event is its rarity. His lucubrations wing their flight into day, seldom as bats flit in the air at noon. Not often grumble we at this, though allusion has frequently been made, in our exposures of the hospital system, to the sad fact, that English medical literature is less indebted to the surgeons of our public hospitals, than to any other class of men in the profession. Moreover we have said, and the statement is unimpeached by one example, that this vile system extinguishes, five instances in six, the little spark of light which may have shown itself in those young men who get appointments in these charities; for, from that time, they cease almost all offerings at the altar of their art. It does seem scandalous that the rich opportunities afforded in those vast establishments, should thus be suffered, year after year, to wane, without one service rendered to the general good, by the medical officers of the charity. Yet so it is. Once perhaps in twenty years a TRAVERS, who should have borne an ox, proves in labour of a pig; or, if he do contribute to the annals of science through the press, produces something — say, on the eye — wherein the least share of experience is derived from the great hospital in which he moves. A BELL, again, in place of hospital cases observed during a dozen years, gives us in the twelfth year, and then is paid to do so by an Earl, a "Bridgewater Treatise,"—and that meant only for the popular perusal. A LAWRENCE will content himself in six long years with serving up at CHURCHILL'S (*restaurateur*), as a new dish, the food he long before presented to the public under another cover. A MAYO saves his learning for that adverse day when thoughtless people have forgotten where he perches, and then promptly issues a well-timed "card" in form of "Observations" on those injuries and diseases to which great folks alone are liable, "price seven shillings; numerous cuts, et cetera." A BRODIE takes such time as a hospital surgeon may reasonably be supposed to spend in serving an apprenticeship to a baronetcy, in trimming an old edition into a new one. A KEY unlocks his stores after a ten years warehousing at Guy's, and gives the world the smallest conceivable quantity of second-hand ware, new furbished for the nonce. A TYRRELL seeing coadjutors busy in their little way, gets busy too, and then magnificently issues forth a syllabus—the literary effort of his hospital life—a syllabus of his last course of surgery,—not the lectures even, but a syllabus—no greater contribution to the trunk trade — made, though, to look as like a book as possible; or, perhaps, pressed for an essay by a newly starting editor, wipes off the dust from some old lecture, and dating it from Bridge Street, *vice* St. Thomas's, tacks at the top a note, and sends it to some work which no soul out of St. Paul's Churchyard sees but the lecturer and our lynx-eyed selves. And so a CARLISLE, whose duties lie at Westminster, concocts in Langham Place a theory which some

MACNAB (*sive* MACNAUGHTY) claims to have raised before him. A COOPER—BRANSBY COOPER—oh! enviable and now immortal name—for whom Sir ASTLEY prayed in court that we would "give him time,"—takes "time," accumulates in Guy's great store of facts, and then puts out, by means of much industrious aid from others,—*three volumes of anatomy*! And now a SCOTT, of London Hospital repute (we might go swimmingly on thus for some minutes more, but here arrest our course), offers, with equal tardiness, fifty-two pages on "tic douloureux and other forms of neuralgia," containing details of sixteen cases, not one of which—*not one*, good readers,—was publicly treated—was treated in the hospital of which Mr. SCOTT is surgeon. Witness the first line of each case as it stands in print. At any rate if there be hospital patients among the lot, Mr. SCOTT has an unusually polite mode of referring to them in his publication:—He thus severally introduces his cases,—1. "A *young lady* now under my care." (Page 9.)—2. "I have at present *two gentlemen* under my care." (Page 9.)—3. "Some time ago, I was consulted by a lady *at Hackney*." (Page 15.)—4. "A *gentleman* about 50 years of age, of a full habit of body." (Page 18.)—5. "A *young lady*, 23 years of age, applied to me on the 24th of February." (Page 19.)—6. "A. G., residing in *Piccadilly*, consulted me on the 17th of March." (Page 20.)—7. "In Nov. 1828, I visited a gentleman *at Hampstead*, labouring." (Page 22.)—8. "Sometime ago a lady residing *at Dover* consulted me." (Page 25.)—9. "On the 23rd of Dec. 1830, I visited a lady in the neighbourhood of *Grosvenor Square*." (Page 26.)—10. "James Burrell, 62 years of age, residing at *High Beech in Essex*, consulted me on the 9th of February, 1829." (Page 31.)—11. "In August, 1830, I visited a lady, *with Mr. Hollis, of Lewisham*." (Page 34.)—12. "Jane Wickham, 73 years of age, *applied* to me in the autumn of 1833." (Page 37.) This may have been a hospital patient, but we suspect from certain details in the case that it was *not*. Any expectation, however, that we have at last got to a division of hospital cases, is dissipated in the very next page.—13. "On the 23rd of Sept. 1833, I visited a lady in *Albemarle Street*." (Page 38.)—14. "A *gentleman* in his 92nd year, on the 3rd of Nov. 1833, consulted me." (Pages 41, 2.)—15. "A young woman, 21 years of age, applied to me on the 4th of Dec. 1833." (Page 42.)—The reader is in doubt about this "young woman," also, until he reads soon after, that "on each *visit*," and at her "next *visit*," she described such and such sensations.—16. "On the 1st of Dec. 1833, I visited *a young lady*." (Page 45.) &c. &c.

This is a pretty good list of private patients for a hospital surgeon to advertise, all "authenticated" by a name without a place of abode, or a place of abode without the patient's name—the full extent of individuality that distinguishes them,—like the A and B and X and Y patients of Dr. Turnbull, who got so roughly handled by some contemporaries, for the precision of address which distinguished his veratria cases,—more roughly, we wager it, than will Mr. SCOTT, a surgeon to a London hospital, by the same critics. Not that we ourselves are so rude as to discredit the word either of Dr. TURNBULL or Mr. SCOTT. On the contrary, we here express our belief, that every case in Mr. SCOTT's pamphlet contains a record of facts which have (so far as he has implied) fallen under his personal observation. As such we shall treat them.

Mr. SCOTT publishes these cases with a view to recommend some forms of local treatment, which have afforded decided relief in a considerable number of cases of tic douloureux, which had proved stubborn to all other remedies. He abjures a *specific* form, as incompatible with a disease so various in its causes. Those causes he arranges (after some remarks on the pathology of the disease, which give us some new opinions founded on old facts) under five heads, viz. plethora of the system, an asthenic state, a gouty or rheumatic diathesis, disorder of the digestive organs, and malaria.

The *plethoric* patient may chance to be relieved from tic douloureux, after every other means have failed, by *bleeding*. Such an event is known to Mr. SCOTT in the case of a gentleman who was at length seized with apoplexy, for which the antiphlogistic treatment was pushed to its fullest extent, when the tic douloureux wholly disappeared.

The *asthenic* case will mend under the *carbonate of iron*, recommended by Mr. HUTCHINSON, on failure of which, Mr. SCOTT has successfully used the *sulphate of quinine* in very large doses.

The *gouty* soul, a frequent sufferer, will benefit by those remedies which correct the morbid condition of his afflicted body.

The *dyspeptic* patient experiences relief from the nervous affection by a restoration of the stomach to its healthy state with active purgatives.

And, finally, those who labour under the disease in consequence of the impressions of *malaria*, and suffer intermittent paroxysms, will be restored by bark and arsenic, as in intermittent fevers.

We now come to passages which we

must, with slight abridgments, extract entire, in order to do justice to the views of Mr. Scott, which, with the advice he founds thereon, are exceedingly judicious, and are preliminary to his recommendation of a *local treatment* of the disease with *mercury*.

"But although the disease, at its outset," says Mr. Scott, "thus depends on constitutional causes, on the removal of which causes the disease will almost invariably subside, in its early stages; if, instead of being thus arrested, it become fixed in the part, its course will continue unchecked: often, too, the best-directed efforts to restore the general health will be rendered perfectly unavailing by the constantly recurring pain and agony, which are so intense as to keep up and aggravate the constitutional disorder; and this is frequently also still further increased by the habitual use of opiates, which, while they fail to relieve the disease, add very considerably to the constitutional irritability of the system. This accounts for the distressing fact we so constantly witness,—that those remedies which may have removed the previous attacks of this disease with perfect facility, do not exert the slightest influence over those which subsequently occur in the same person, although they are precisely of a similar character. It is under these circumstances that local treatment becomes of paramount importance; and as this is the point on which I am anxious to insist, I wish particularly to guard against the impression that I recommend its indiscriminate use without reference to the particular circumstances of each individual case.

"Some years ago, when I was trying the efficacy of the local influence of mercury in arresting chronic inflammation of the various structures in the body, with a view to illustrate the treatment of diseased joints on this principle, I met with several cases of tic douloureux, which had resisted every remedy that could be devised, and I determined to subject them to that mode of treatment which I had found so successful in what I believed to be a similar condition of other textures.

"The plan I adopted was to keep constantly applied to the part, on a piece of flannel, an ointment composed of one drachm of *tartarized antimony* and an ounce of *mercurial ointment*, renewing it as frequently as it could be borne, the object being to produce such a degree of irritation on the skin as would ensure the mercurial influence on the part. This method was attended with very considerable success, but I have not preserved any record of the cases in which it was employed at this time: it was in consequence of the benefit which a patient derived from this remedy that I was consulted on the following case.

Case 1.—"James Burrell, 62 years of age, residing at High Beech, in Essex, consulted me on the 9th of February, 1829, and the first attempt to describe his complaint produced a violent paroxysm, attended with so great contortion of the face, as at once to indicate the nature of the malady. His daughter, as he was himself unable to articulate, informed me that when able to speak, he described the pain as commencing just in front of the ear, and darting thence up towards the forehead, which he compared to a burning iron thrust into the part in this direction."

A dozen remedies had already failed to touch the disease, when Mr. Scott took it in hand, and thus concludes the case:—

"I directed some opening pills to be taken every second night, and the mercurial ointment, with tartarized antimony, to be applied to the face on a piece of flannel. This application produced great irritation on the skin: but after its employment for a fortnight, the paroxysms were decidedly removed, and in a month he was perfectly well. He lived till July, 1833, without having any return of the disease, and then died of some other complaint.

"It subsequently occurred to me, that the iodurets of mercury, particularly the deuto-ioduret, would be a much more effectual remedy than the preceding application; producing more speedily such an abrasion of the skin as would subject the part to the mercurial influence; and the following are cases in which this mode of treatment has been adopted,—using the deuto-ioduret, the proto-ioduret of mercury, or the common mercurial ointment, according to the state of the skin; the object being to produce such an effect upon the part as would control the disease, and to keep up the impression of the remedy to such an extent, and for such a length of time, as would remove the morbid condition of the nerve."

The disease was various in its seat, excessive in severity, and incurably obstinate against all other remedies, in each case. The following may be received as a digest of the cases:—

Case 2.—Mrs. W., 50 years of age, having suffered intense anxiety, in January 1832 began to suffer almost insupportable pain in the gum, tongue, and right lower jaw, which radiated from the point of emergence of the third branch of the fifth pair of nerves. Having in vain tried quinine, carbonate of iron, arsenic,

belladonna, musk, colchicum, &c., during eight months, Mr. Scott says,—

"I directed an ointment composed of two scruples of the *deuto-ioduret of mercury* and an ounce of lard to be rubbed on the part night and morning, until it produced as much irritation as would relieve the spasms. On the 1st of September she had one short but violent spasm. The ointment was continued more or less frequently, according to its effect, until the 14th; and during the whole of this time she remained perfectly free from any return of the spasms, which had not been the case, even for a single day, for the previous eight months; indeed, she felt herself so completely relieved, that she imprudently discontinued the use of the ointment, for the purpose of visiting a relation at a distance. On the 24th of September she returned home; and although she had experienced no return of the spasms, there still remained an uneasy sensation in the part, which proved that the disease was not completely removed. The application was accordingly resumed, and applied at intervals, determined by the state of the skin, so as to keep up a slight effect upon the surface, until the 12th of October, and she had no recurrence of the spasms."

Case 3.—"On the 23rd of September, 1833, I visited a lady in Albemarle-street, who was labouring under a very severe attack of tic douloureux in the supra-orbitar branch of the fifth pair of nerves on the left side. * * * * I directed the opium and all other remedies to be discontinued, and applied the *deuto-ioduret of mercury*, spread on lint, to the part affected. This very shortly produced vesication of the cuticle, and its effect on the disease was instantaneous; for in the first twenty-four hours after its application, she experienced only three paroxysms of pain, whereas they had been previously incessant; on the following day they were rather more frequent, and continued to recur occasionally in a very slight degree during the three succeeding days, after which they ceased altogether. The ointment was renewed as frequently as the skin would bear its application, and was varied according to the effect it produced; sometimes the proto-ioduret of mercury was employed, and sometimes the common mercurial ointment, so as to keep up the influence of the remedy on the part for a fortnight, when it was entirely discontinued.

"This patient continued free from any recurrence of the disease until the 19th of January, 1834;" when, "and at subsequent times," she was seized with very severe paroxysms of pain in the same situation as before.

"The ointment was on each occasion immediately re-applied, and again checked the disease. Although the disease was thus decidedly influenced by the remedy on each time of its application, as soon as the effect was allowed to subside it immediately recurred, and this I attribute to the irritation the nervous system was labouring under at the time, from a very disordered condition of the digestive organs, which was evidently the exciting cause of the attack. Indeed, there was very considerable difficulty in obviating this disordered condition; the most active medicines being necessary, throughout the progress of the case, to promote a natural state of the secretions, which, for a very considerable time, resumed their former unhealthy appearance immediately on its being discontinued."

Case 4.—"A gentleman in his 92nd year, who had been occasionally subject both to gout and rheumatism, was first attacked with tic douloureux in the year 1831, affecting both the supra and infra-orbitar branches of the fifth pair of nerves. On the 3rd of November, 1833, I was consulted, and applied the *deuto-ioduret of mercury* in the usual manner: it produced considerable inflammation of the skin; but the pain attending it was so much less severe than that of the original disease, that he did not complain of it. The paroxysms continued with their accustomed frequency and severity for three days, and then they began gradually to subside, becoming less frequent and of shorter duration, and some days he was free from pain during the whole day. The application was renewed once in ten days or a fortnight, and each time with a decided influence on the paroxysms; but they showed a disposition to return as soon as its effect upon the skin had subsided, although they were comparatively slight, and much less frequent than before. When the skin was perfectly healed, the paroxysms began to recur: under these circumstances the ointment was again applied, and renewed as frequently as would keep up such an effect upon the skin as was necessary to control the disease. The paroxysms became gradually less frequent until Sunday, January the 5th, 1834, when they ceased entirely, and did not subsequently return; but it was considered prudent to keep up the effect of the application on the part for some time afterwards."

Case 5.—"A young woman, twenty-one years of age, applied to me on the 4th of December, 1833, on account of a

constant distressing pain in the left breast, which was so severe at night as entirely to deprive her of rest. There was no tumour or swelling of any kind in the breast. The symptoms were usually more severe three or four days before the occurrence of the monthly periods. The disease had commenced ten months before, without perceptible cause. During the whole time she had been under treatment without deriving benefit. At the time of my seeing the patient, the surface of the breast was still sore, from the irritating applications that had been used; I therefore applied *proto-iodurel of mercury*, in the form of ointment, at the same time supporting the breast by adhesive plaster and a bandage. The applications were renewed every week; and on each visit she described the constant pain to be gradually lessened, and the acute lancinating pains to be also less frequent and less severe. Soon after the 25th of December she stated that she felt no inconvenience of any kind in the breast."

Case 6.—"On the 1st of December, 1833, I visited a young lady, who was labouring under the most distressing neuralgic affection I ever witnessed. The left knee was the seat of a constant aching, gnawing pain, which was referred to a considerable extent of its surface, whence it darted into the centre of the joint, extending also upward to the middle of the thigh; and the surface of the knee was so exquisitely sensitive, that she could not bear the slightest touch, nor even the weight of her ordinary clothing. The disease commenced in February, 1831, when some degree of stiffness and uneasiness was first experienced in the joint; and she had been confined by it to the same couch, day and night, for nearly three years. On the 1st of December, I applied the *deutoiodurel of mercury* to the knee, thickly spread upon lint; and it is a remarkable circumstance, that this application was renewed several times, without producing the slightest effect upon the skin. This being the case, on the 24th of December I rubbed the surface of the knee with camphorated spirits of wine, so as to make it quite red, and then applied the ointment, very thickly spread on lint; the consequence of this irritation was a spasm which lasted without intermission thirteen hours and three quarters, when it suddenly subsided, and left her quite exhausted, but being free from pain she slept for several hours. The effect of the ointment was extremely violent; it blistered the surface to the extent of its application, and also produced copious salivation. The spasms continued to recur as usual for two or three days, and then began sensibly to lessen both in frequency and in severity; and on the 1st of January she had no spasm at all, which was the first day she had been entirely free from spasms for nearly three years: the aching pain still continued, but was very considerably diminished in violence. She continued free from any recurrence of spasms until the 14th of January, when one or two were produced by some accidental movement of the limb, the effect of the ointment having at this time entirely subsided, the surface of the knee being perfectly healed, the ointment was immediately re-applied, and renewed as frequently as would keep up some degree of soreness of the skin, but not carried to the extent of producing the slightest constitutional influence; and it was found necessary to continue the application for a very considerable time, to wear out the morbid disposition which disease of so long continuance must necessarily have induced. On the 21st of January she left the couch, and shortly afterwards the room in which she had been so long a prisoner. She then gradually acquired strength, and was soon able to walk on the limb, with the aid of crutches."

This case is rendered additionally interesting by the record of the following fact; that in consequence of the occurrence of a severe neuralgic affection of the throat, the patient was recommended by Mr. Pennington to abstain altogether from taking food by the mouth, in lieu of which "nutrient enemata were administered twice or thrice a day, composed of beef tea with an egg dissolved in it, for which veal broth and milk were afterwards occasionally substituted. At this time the secretions were much disordered; there had been no appearance of the catamenia for nine months; the pulse was frequent, quick, and irregular. After pursuing the plan just named, for four days, very considerable excitement was produced, attended with some degree of fever, quick pulse, and flushed cheeks, &c., but it shortly subsided, the pulse becoming less frequent, and the fever disappearing. At the end of a fortnight, bilious secretions were observed, and in a month the catamenia re-appeared; the pulse was between 70 and 80, and not deficient in strength. *After the lapse of five weeks and three days, without any nourishment being introduced by the mouth*, the pulse suddenly sank to 35 in a minute, and it was then deemed advisable to give by the mouth a dessert-spoonful of beef tea twice a day; and this being continued for four days without inducing any return of the spasms, a small piece of fish was then allowed, and after-

wards some chicken; and proceeding thus cautiously, in the course of a month she was able to eat and drink any thing without the slightest inconvenience."

For the style and extent of details in any of the cases we have given, Mr. SCOTT must not be held to be responsible. They are considerably abridged, but abridged only of those parts which are not essential to a comprehension of the principles and mode of treatment recommended by the author.

Yearning for reform in our hospitals we have taken this opportunity of again exposing one effect of its absence. They are institutions which, as far as the promotion of any useful scientific object is concerned, might almost as well be closed, unless the present system of elections in them be changed. Of the tens of thousands of cases yearly treated within their walls, the published records for the last fifty years would not—no, nor would the private—fill one shelf of a common library. Even in the pamphlet before us, the author has failed to quote a single fellow labourer in the hospitals, for information on the disease discussed. He refers to CIRILLO, to CHAUSSIER, to DELPECH, to ROUSSET, all foreigners; to PARRY, SWAN, HUTCHINSON, FOTHERGILL, and BAILEY, all practitioners out of the great hospitals. He quotes no others.

With respect to the deserts of the pamphlet, we request the profession to estimate them by a trial of the treatment prescribed.

COMPLAINT OF STUDENTS THAT THE

POST-MORTEM EXAMINATIONS

OF

PATIENTS WHO DIE IN THE LONDON HOSPITALS

ARE CONDUCTED

IN SECRET.

To the Editor of THE LANCET.

As you have always shown a readiness to hear, and a wish to redress any evil which affected the medical pupil, I do not know to whom I could better apply than yourself, to expose the negligence of our hospital functionaries in the present matter, and through your journal let me hope the subject will attract the attention of MR. WARBURTON.

Sir, it has become a general complaint among the students that no due notice of post-mortem examinations is given in the hospital. Believing this to be the case, and knowing it is so at the hospital I attend, I am induced to ask your aid publicly to notice the omission; for by this means I have no doubt it will be removed. In our hospital, post-mortems continually go on without any one knowing of them, save a favoured few (the clinical clerks). Occasionally, it is true, there is a notice put up within the glass case kept for that purpose, but it is seldom replaced by a fresh one, and may frequently be seen sticking in the same place a month or more after the examination has taken place. If a proper notice were given, stating the time, patient's name, and disease, the student would then be able to judge as to whether he could conveniently attend, or whether the case would be sufficiently interesting to claim his attention. As matters now stand, those who attend particularly the practice of one physician, or who have to attend surgical practice at the same time, are deprived of the opportunity of attending all the post-mortems, from not knowing of the deaths, and not having any notice to inform them when they happen. An early notice of this complaint, especially as hundreds of students are on the eve of coming to London for the new session, may do much good, and will oblige, Sir, your obedient servant,

A PUPIL OF THE MIDDLESEX HOSPITAL.

ST. GEORGE'S HOSPITAL.

CLINICAL REMARKS. BY SIR B. BRODIE.

HYDROPHOBIA.—In alluding to a patient who had been admitted a few days previously from the bite of a dog, supposed to be mad, Sir B. BRODIE observed, that the fact of the dog running in and out of the water a few minutes previous to the infliction of the bite, was no proof that the dog was either mad or not mad, as animals did not show the same symptoms of the disease as human beings. The symptoms of hydrophobia (he remarked) should generally be regarded as showing themselves between the fifth and ninth weeks, that is, within the period of the second month after the infliction of the bite. He had heard of cases occurring in the ninth, fifteenth, and nineteenth weeks after the accident, but such cases were rare. It was a matter of the greatest importance to ascertain the average period at which the disease showed itself, as practitioners were then able to ease the patient's mind, and relieve their own from feelings of anxiety. In answer to a gentleman who inquired whether the suction produced by cupping-

glasses over the wounded parts was not preferable to either the knife or the caustic, Sir B. BRODIE answered, that he did not think it was; and that the excision of the parts was decidedly the best plan of treatment. One case was here related, in which a patient afflicted with hydrophobia had the part excised by Sir B. BRODIE, and a gentleman who was by, passed a probe *through* the excised portion of skin, showing that the incision had been carried *deep* enough. The same circumstance happened to Mr. HUNTER, at *St. George's Hospital*. The following case was also narrated:—A man who was catching cats endeavoured to dislodge some of them by poking at them with a pole, in doing which one of them flew at his hand, and bit it. A week afterwards the man came to the hospital with symptoms which so much resembled those of hydrophobia, that the house-surgeon (who had never seen a case of the disease, but had only read of it in books) set it down as that disease. Sir B. BRODIE, however, who had seen cases of the kind, at once detected the difference (which was, indeed, but very slight), and the man ultimately recovered. Sir B. BRODIE observed, that there was something in the infection and reception of the disease from an animal that we did not yet understand; as he had known a case in which a man who was bitten by a dog which was *supposed* to be mad, died in the course of six weeks, while at the end of the fifth week the dog was alive and well.

NEW MEDICAL SESSION.

THE next number of THE LANCET will contain such information and advice, addressed to medical students who visit London in the ensuing October session, as we may deem it advisable to offer to them at this season of the year. The number will, in accordance with our annual custom, be entitled, THE STUDENT'S NUMBER.

CORRESPONDENTS.

Mr. Editor,—Knowing you long as the willing drum-major of our corps in cases where punishment has been *justly* decided on, may I, in the name of myself and others, beg of you to apply the lash to the editors of the *Cyclopedia of Practical Medicine* for their negligence or breach of faith. The work professes to come out *monthly*, but the last number appeared in April, *five months since*. It ought to have been completed, according to arrangement, in January, 1834; it is now nearer 1835, and we have still five or six numbers more to expect; so that we poor subscribers have to look forward another year or two for its completion, by which time, in these publishing days, it will be an oldish work. The profession should not be led to subscribe to works, the protraction of which, to an indefinite period, is not better provided against. Your obedient servant, R. O.

September 16th, 1834.

Indicus labours under an apprehension (wrongly we think) that the extract made in THE LANCET of September 6th, from the *Jamaica Physical Journal*, relative to the College of Physicians and Surgeons in Jamaica, will create an erroneous impression. He, therefore, wishes us to say, "That this Board in Jamaica is simply established to prevent *incompetent persons* from practising in the island, which could be possible, as up to that period there was no law to hinder them. No diploma from the Board is intended to allow parties to practice elsewhere. Indeed no diploma is given. Those who intend to qualify themselves for medical practitioners still leave the island for English schools and certificates."

Mr. Bedingfield does not say whether he has examined Mr. Offord's instrument in its new form. We cannot therefore at present give publicity to his opinion.

W. The object of the author, not the contents of his book, formed the text of the criticism. The contents were generally good, and so declared to be. The exception we shall allow to be corrected in the manner desired by our correspondent, but without allusion to the author mentioned, to whose alleged error we gave no publicity.

Mr. B—d. The passage had no kind of reference to Mr. H. B., and was, plainly enough, communicated by Mr. W.

We have received communications from *Mr. Bird*, *Mr. Landsdown*, *Mr. Spilsbury* (cases of lithotrity), *Mr. Dermott*, *A Governor of Christ's Hospital* (in reply to Mr. Field), and W., the whole of which are in type, but are excluded, in consequence of want of room, from this week's LANCET.—The letters of *A Physician* (Ramsgate), *Mr. Hunter*, and *Mr. Paul*, have been received.

Mr. Taylor, of Gower-street, has in the press "The Surgeon's Practical Guide in Dressing, and in the Methodic Application of Bandages." By Thomas Cutler, M.D., late Staff-Surgeon in the Belgian Army. Foolscap 8vo. Illustrated by numerous engravings on wood. Also,

"The Principles of Ophthalmic Surgery; being an Introduction to a Knowledge of the Structure, Functions, and Diseases of the Eye, including the Author's new Views of the Physiology of the Organ of Vision." By John Walker, Assistant-Surgeon to the Manchester Eye Institution. Foolscap 8vo.

"Sine fuco," &c. The system will be entirely changed.

LECTURES
ON
COMPARATIVE ANATOMY AND ANIMAL PHYSIOLOGY,

BY

ROBERT E. GRANT, M.D., F.R.S.E., &c., &c.;

Fellow of the Roy. Coll. of Physicians of Edin., and Professor of Comparative Anatomy and Animal Physiology in the University of London.

LECTURE XLIX.

ON THE SANGUIFEROUS SYSTEM IN THE VERTEBRATED CLASSES.

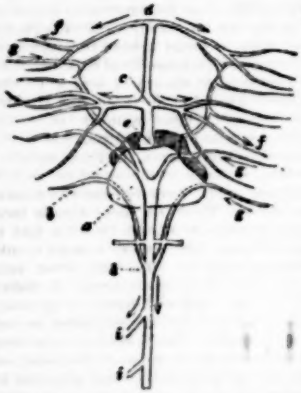
As the fountain of all nourishment and of all development is the blood, the peculiarities of the sanguiferous system in the different classes, and the laws which regulate its distribution in different animals and in different parts of the body, must involve the chief mystery of animal development and of animal forms. The various conditions presented by this system in the vertebrated classes are but the links of a continuous chain of developments extending from the lowest animalcules, and the vascular system of man passes through all these phases of development before arriving at its perfect state, so that we cannot fully perceive the relations of any part of this general process without a knowledge of the whole. As the sanguiferous systems of the fish and the reptile are but different stages of the development of those of the bird and the quadruped, it is by a knowledge of the former that we can best comprehend the various conditions of the latter, and man's development can thus be studied without as well as within his body.

The lowest vertebrate condition of the vascular system is that presented by the fishes, and we have been gradually led to this condition by tracing the development of its separate parts throughout the invertebrated classes. The circulating system of the adult fish is that of the young tadpole, but so similar are the forms through which this system passes in all the vertebrated classes that we may look upon the fishes as permanent larvæ, not merely of amphibia, but of all the higher animals and man. Fishes move and breathe in a dense element where the material is scanty to oxygenate the blood, yet they require rapid and extensive aeration from their high development, their muscular force, and their high position in the scale; hence those mutable organs the gills, through which their whole blood must pass, are placed, not behind the heart as in the slow-creeping mollusca, but before it, to benefit by its impulse in the important function of respiration. We have seen that the slow-moving gasteropod requires a comparatively complicated and a powerful heart to propel the blood through the labyrinth of its languid frame, while its exposed ciliated gills are bathed incessantly in the surrounding element, so that they require no aid from the heart for their indifferent respiration, but all its energies to circulate nourishment and life through their languid system. The fish has still the simple bilocular heart and the gills of the mollusca, but by transposing these organs the whole energy of the heart is added to the respiratory organs, and the power of that respiratory function is doubled. Indeed a respiratory organ is but an artery ramified where its capillaries may best reach the outward element, and that vessel may be a twig, or a branch, or the whole trunk of the arterial system, as it is with the fishes. The highly developed muscular system of the whole body of fishes is to them a systemic heart which keeps their aerated blood in rapid movement through every part, and the active period of the amphibia is their tadpole state, when they also require no separate systemic heart to impel the vital currents through their body. The blood of fishes is more red and fibrinous and coagulable than in the invertebrated classes, but circulates so sparingly through the system that their viscera are pale and their muscles white, and it is still cold from their limited respiration, their whole inferior development, and the limited energy of all their chemical functions.

The venous blood is collected from the anterior and posterior parts of the body by two great venæ cavæ, which generally unite and enlarge to form a sinus venosus between the tendinous diaphragm of fishes, and the proper auricle of the heart. The heart, situated far forwards, under the head, and between the anterior terminations of the branchial arches, is enclosed in a thin pericardium, which embraces also that enlarged muscular bulb at the commencement of the branchial artery, the bulbus arteriosus. This sinus venosus is sometimes capacious, strong, and marked with muscular bands, like an auricle, and there are commonly two crescentic valves at its entrance into the auricle, to prevent the return of the blood during the contraction of the wide, thin, capacious auricle. The whole heart is situated a little farther back from the head in the cartilaginous than in the osseous fishes, and still farther back in the amphibia and the reptiles and higher classes. In the horizontal po-

sition of the fishes the auricle lies above the ventricle, or towards the back, and it advances more forwards in the cartilaginous fishes, as in the rays and sharks than in the osseous and inferior fishes. Now as these cavities of the heart are first formed in a continuous straight line, in the fishes, as in the other vertebrated classes, we perceive the greatest deviation from the primitive position of the auricle in the highest cartilaginous fishes, and this difference of position marks the higher development of their heart, and its nearer approach to that of the more elevated classes, where it mounts forward to occupy the anterior part of the ventricle. The auricle is more capacious and has thinner parietes than the ventricle, it commonly extends so much transversely as to envelop the dorsal side of the ventricle, and to appear beyond it on each side. In the *ray* (*Fig.* 171, *b*) you observe the au-

Fig. 171



ricle extend forwards so as to overhang the ventricle and encompass its dorsal surface. The muscular bands are obvious in the interior parietes of the auricle, but this wide sac has not yet developed those fringed marginal extensions which it commonly presents in higher classes. It is the first cavity enclosed within the pericardium, as the sinus venosus is between this sac and the anterior tendinous limit of the abdominal cavity. The blood from this large soft auricle enters the thick muscular ventricle (*Fig.* 171, *a*), near its anterior part, where there are two strong semilunar valves with loose free margins, like those between the auricle and the sinus venosus. Sometimes this auriculo-ventricular or mitral valve consists of three or even four parts, but without tendinous cords to strengthen their margins, excepting in the cartilaginous fishes. The ventricle is comparatively small, has generally in the osseous fishes an angular and tapering form, becoming smaller towards the anterior opening into the bulbus arteriosus, and in the cartilaginous fishes is rounded, depressed, and expanded transversely, like that of the chelonian reptiles above them in the scale. Its interior is provided with very thick and prominent fleshy columns, and its colour is lighter or paler than that of the auricle, and darker than that of the strong white muscular bulbus arteriosus. The ventricle is developed transversely in the higher cartilaginous fishes to prepare it for the division of its cavity into two parts, which is gradually effected in the class of reptiles. At the opening of the ventricle into the bulbus arteriosus (*Fig.* 171, *e*), or the thick muscular origin of the branchial artery, there are again two simple crescentic or semilunar valves to prevent the return of the blood into the ventricle, and to support the column of fluid during the contraction of this muscular part of the branchial artery. We observe that throughout the cavities of the heart in fishes there is still this simple semilunar form of the valves, which we saw in the cavities throughout the invertebrated classes, and which is found in the valvular folds of the veins, and even in the chyliferous and the lymphatic vessels of the highest vertebrata.

From this single ventricle of fishes, the blood is propelled into the bulbus arteriosus, which varies much in its form and magnitude, but has always thick muscular parietes, and appears generally, from its magnitude, to be like an additional ventricle placed anterior to the other. This large, round, thick, muscular sac, which you observe in the *lophius*, at the commencement of the branchial arteries, is the bulbus arteriosus. That bulbus arteriosus we saw already developed in the cephalopods, and traces of it as low as the conchifera, so that it is not a new part in the class of fishes. It is the means prepared by nature for the division of this great arterial trunk into a systemic and pulmonic vessel in higher classes.

Thus then the blood, aided by all those muscular cavities, is propelled into a great single branchial artery which subdivides into branches corresponding in number with the gills on each side. In all fishes, and perhaps in all the vertebrata, this artery appears at first to divide into five branches on each side. In the sharks and the rays, and in other cartilaginous fishes, we most frequently find in the adult state these five trunks distributed on each side

to the branchiæ. The fifth, in most osseous fishes, has been converted by a partial metamorphosis into vessels going to the head. Thus then we observe there is a change in the function and destination of the anterior pair of branchial arteries. This metamorphosis of the anterior pair of branchial vessels we observe in most of the osseous fishes, but there are four pairs permanently retained of those branchial arteries corresponding with the number of the gills retained upon each side of the neck. Those branchial arteries (*Fig.* 171, *c, d, f*) soon subdivide to an extreme degree of minuteness upon the delicate laminæ that compose the gills. We observe that the branchial artery, conveying the venous blood along each gill, occupies the exterior portion of the groove of the branchial arch, and has beneath it the returning branchial vein, which we observe running along the bottom of the groove in the cartilaginous or osseous arches supporting those gills. Here the branchial arteries subdivide into innumerable minute capillaries that are continuous with the branchial veins. The branchial veins (*Fig.* 171, *g, g*) thus reinforced by a continued accession of capillaries are enlarged as they proceed backwards, and receiving all the arterialized blood from the gills, they convey it into larger anastomosing branches at the back part of the trunk, which immediately send forward the principal arteries of the head. The great trunk (*Fig.* 171, *h*), constituted by the successive union of all the branchial veins, forms the descending aorta which conveys the blood through all parts of the back, the abdomen, and the caudal region of the body. The arterial branches going to the head proceed from the dorsal part of the anterior branchial veins, so that they convey forwards to nourish these parts blood newly arterialized, by passing through the gills. The other branchial veins, behind the front pair, also give off branches (*Fig.* 171) conveying arterialized blood, and performing the functions of arteries to the surrounding parts on the anterior portion of the body, as the heart, the pericardium, the operculum. The principal trunks, however, of the branchial veins (*Fig.* 171, *g, g*) continue upwards from the gills, and by their union into one great trunk (*Fig.* 171, *h*) below the bodies of the dorsal vertebræ, form the abdominal aorta, which keeps along the median plane beneath the vertebral column, in its passage backwards to the coccygeal region, where it becomes enclosed throughout its course by the inferior converging laminæ of the vertebræ.

The large cœliac artery (*Fig.* 171, *i*) distributing blood to most of the abdominal viscera, arises from the commencement of this aortal trunk. Within the abdomen lateral branches come off at regular distances, one pair for each vertebra, which supply all the contiguous, muscular, osseous, and cutaneous parts, and send down branches as renal arteries to the long narrow kidneys extended along the sides of the vertebral column. The aortal trunk continued single along the inferior ring of the coccygeal vertebræ is situate above the vein which occupies the same canal, and it sends off regular pairs of branches passing upwards and downwards on each side to supply the muscular and other parts of the tail. This venous trunk running forwards enclosed in the inferior rings of the coccygeal vertebræ, and placed beneath the aorta in the same canal, is the commencement of the vena cava, which continues forwards along the abdomen, under the bodies of the vertebræ and still under the aorta, collecting the venous blood chiefly from the surrounding muscular parts, and ultimately terminates in the great sinus venosus behind the auricle of the heart. The venous blood collected from the chylopoietic viscera is sent to be distributed through the large and divided liver, by a variable number of trunks forming so many venæ portæ, and sometimes the long lobes of the liver, attached between the turns of the intestine, receive the venæ portæ directly from the mesenteric veins. This is a more simple form of the portal circulation than we find in higher classes where these venous trunks generally unite to form one great vena portæ before entering the liver. In fishes, as in several higher classes of animals, there is a renal portal circulation as well as an hepatic. The kidneys extending along the whole abdomen to the head, exterior to the peritoneum and attached by cellular substance and vessels to the sides of the bodies of the vertebræ, receive numerous branches and nearly the whole contents of the great venous trunk extending forwards within the upper rings of the vertebræ. This venous trunk lies above the spinal chord in the same canal, and appears to distribute through the kidneys, by numerous descending lateral branches, the venous blood which has been collected from the dorsal and caudal parts of the body, before it is transmitted to the venæ cavæ. The number of venous trunks which convey the blood to the sinus venosus varies, but most frequently there are two great venæ cavæ. In the *rays* there are considerable sinuses both on the two venæ cavæ and on the hepatic veins behind the diaphragm. It has been imagined from the venous circulation through the

kidneys, that the urine, like the bile, is formed chiefly from venous blood in the lower classes of vertebrated animals.

In the perch the sinus venosus is of very great size, as you see figured by CUVIER in his folio plates of the structure of this animal, and there is another sinus at the back part of the cranium which collects the blood of the head before being transmitted to this great sinus venosus behind the pericardium. The bulbus arteriosus in this animal has the pyramidal form most common in osseous fishes, with strong longitudinal and circular fleshy bands composing its parietes, and the usual semilunar valves at its commencement, but in the cartilaginous fishes it has a more lengthened cylindrical form with numerous small semilunar valvular folds disposed in rows on its inner surface, besides the ordinary valves at its origin. The number of rows of these little valves, and the number of valves in each row, vary very much in the different cartilaginous fishes, and they are often provided with tendinous cords, still further to secure the regular flow of the blood forwards during the contraction of this thick muscular tube, and during the violent exertions of these muscular animals. Some sharks have only two rows, some have three rows, and there are five rows of these small valves in the bulbus arteriosus of the common skate (*Fig.* 171 *e*). In the sturgeon there are three rows of valves, two small rows near the ventricle, and a third row of larger valves at the anterior termination of the muscular part of the bulb, each row having four valves, and all arranged in regular order.

At the anterior extremity of the bulbus arteriosus in the skate the thin portion of the branchial artery gives off on each side a short trunk (*Fig.* 171 *c*), which immediately divides into the three posterior branchial arteries of that side. The trunk then continues forwards to the anterior pair of branchial arches, where it gives off on each side another short trunk which soon divides into the two anterior branchial arteries of that side. From the gills being fixed both at their outer and inner margins in these cartilaginous fishes, the arterialized blood is collected from all the minute laminæ by two branchial veins for each gill. These branchial veins, before they leave the gills, give origin to small arterial vessels to nourish the anterior and adjoining parts of the body, and then pass backwards uniting into larger trunks to form at length the great single systemic aorta which supplies the viscera and nearly the whole trunk of the animal.

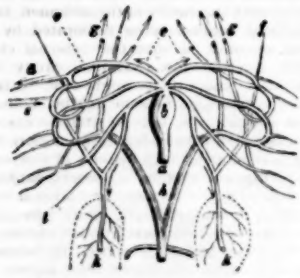
The bands so frequently found in fishes connecting the heart to the pericardium, as in the sturgeons and lampreys, appears to be a remnant of that connexion of the heart with the surrounding parts so common in the invertebrated classes, especially in insects, crustacea, and other articulated animals, and the cavity of the pericardium is frequently found to have a free communication with the cavity of the abdomen, the tendinous septum being perforated by a wide opening, so that the external element entering the abdominal cavity by the lateral anal orifices might reach to the heart in fishes, as in some of the molluscous animals. So that we find the vascular system in fishes advanced not only by the development of a distinct chyliferous and lymphatic system of vessels, but also by that of a new hepatic, and a renal circulation of venous blood, which have not been traced in the invertebrated classes.

We have already seen that the amphibious animals commence their career as fishes, having but one auricle and one ventricle, and breathing solely by means of gills in their tadpole state, and sending the whole of their blood through those aquatic respiratory organs; but as they advance in their development their air-sacs are converted into lungs, and the arterialized blood collected from these air-breathing organs develops a little sinus on the united trunks of the two veins which return it to the ventricle. As the respiratory lungs develop in extent and importance, this sinus, receiving their arterialized blood, becomes a small but distinct pulmonic auricle, separated by a thin transparent septum from the systemic and larger auricle, and provided like it with valves at its entrance into the ventricle. This was observed some eight years ago, in 1825, by Dr. DAVY, when dissecting and experimenting on some toads and frogs in the island of Corfu, and his observations have been verified and extended by succeeding anatomists, especially by WEBER, who has shown the same structure to pervade the lowest perennibranchiate amphibia, as the proteus and the axolotl. Now the changes through which the vascular system passes during the metamorphosis of the fish-like tadpole to the reptile-like adult amphibious animal, were long since traced with great skill and accuracy by RUSCONI, and the same curious changes of the vascular system which have been so often traced during the metamorphosis of the amphibia, have more recently been traced by numerous observers through all the vertebrated animals, and man himself.

The heart of the tadpole, like that of the fish, consists of an auricle which receives the venous blood of the system, and a

ventricle which propels it into a bulbus arteriosus (*Fig.* 172, *a b*), to be sent through as many branchial arteries (*Fig.* 172, *c d*) as there are gills on the sides of the head. There are most frequently three branchiæ on each side, as here in the salamander, *triton cristatus* (*Fig.* 172, *c*), and the blood

Fig. 172



which has been aerated in these gills is collected by a corresponding number of branchial veins (*Fig.* 172, *e*), which by their union form the descending aorta (*Fig.* 172, *h*) after giving off branches to the head and neck as in the finny tribe. The trunks of these branchial arteries and veins communicate by very minute and short canals at the base of the gills, and as the gills are absorbed and disappear, these communicating portions widen and at length become parts of the continuous trunks. The small branches sent off from the branchial veins to the head also enlarge and form great arteries. A very small artery is seen on each side coming off from the posterior branchial arteries near to the heart, which go to the little pulmonary sacs that are beginning to develop, and when the lungs are developed, and the gills are lost, and the branchial arteries and veins have shrunk inwards to form continuous wide arterial trunks for the system, these two small twigs going to the rudimentary air-sacs (*Fig.* 172, *k*, *k*) enlarge in size and form the great trunks of the pulmonary arteries. The branchial veins conveying arterial blood in the tadpole, form by their union the descending aorta, and we observe coming off from the third or posterior of these branchial veins on each side, an artery going to the lungs. This pulmonic branch, at first the larger, diminishes in size as the other, from the posterior branchial artery, increases, and at length it shrinks to a mere ductus arteriosus leading from each pulmonary artery into the lateral branches of the descending aorta. The first change in this metamorphosis from the condition of the fish appears to be the formation of communicating canals between the branchial arteries and veins, which paves the way for all the succeeding alterations; and MARTIN SAINT-ANGE, who has very satisfactorily illustrated these changes of the vessels in the *salamander* in the figures he has just published, thinks that the perennibranchiate amphibia are forced to retain their gills through life, notwithstanding the usual development of their pulmonic system, by the want of these anastomosing or communicating canals between the branchial arteries and the branchial veins which alone permit the important changes of the vascular system which accompany the losing of the gills in the caducibranchia. These communicating twigs that are seen passing from each of the branchial arteries to the corresponding branchial veins enlarge by the metamorphosis to such an extent that they form at length continuous arterial canals upon each side. The gradual obliteration of the exterior ramified gill portion of these arterial and venous trunks thus tends ultimately to form one continuous descending branch or arch of the aorta on each side, which we observe to exist in these adult animals, as in all the higher cold-blooded vertebrata.

Some of the arteries proceeding from the branchial veins are enlarged to that extent, which were before minute capillaries, that they now form important trunks, going to supply all the upper parts of the body, while the great trunks are continued downwards as two arches, to unite in the middle of the dorsal part of the trunk, to form the single abdominal aorta. Thus it is that we find that the trunk of the pulmonary arteries is sent off only as a branch from the aorta, which conveys the blood to the respiratory organs in the adult animals, which organs are sometimes cellular, as in the frogs, sometimes simple undivided sacs, as in the tritons. In the frog, you observe that these changes of the vascular system have proceeded to a greater extent of deviation from the fishes, than either the perennibranchiate species or the tritons, which still remain in the water, though they have lost their gills. The sinus venosus is large in the adult amphibia, as in the fishes, and receives all the systemic blood before it enters the large thin right auricle of the heart, which propels it into the single, muscular, thick, light-coloured, and soft ventricle. The sinus venosus in the triton is a large round muscular cavity, like the right auricle. During the dilatation of the ventricle in the frog, the red blood is seen to penetrate and fill all the loose porous fibrous parietes of that cavity to its outer membrane, and thus to give it

a deep-red colour for a few seconds; but during its contraction, which a little precedes that of the bulb at the origin of the great systemic and pulmonic arteries, the ventricle assumes a white colour, and its blood, partially mixed by this loose texture, is prevented from returning into either auricle by small semilunar folds surrounding the auricular orifices, as pointed out by Dr. Davy. The two auricles are, however, easily inflated, especially the pulmonic, which is smaller and less perfectly protected, by placing the blowpipe in the opened ventricle, as proposed by Davy, and by thus filling them with air we distinctly perceive their fibrous or muscular structure, and the thin diaphanous, but complete and imperforated partition between the auricles. By inflating the two venæ cavæ, or the sinus venosus, we distend the right auricle, then the ventricle, and by inflating either of the pulmonary veins, we distend the small left auricle, and then the air escapes into the ventricle. From the ventricle come off the two great systemic trunks and the two smaller pulmonary arteries, the whole enlarged at their origin by the bulbus arteriosus, which is already partially divided by a septum. The auricles are still more advanced over the upper and fore part of the ventricle, than the auricle even of the cartilaginous fishes, and the whole heart is placed further forwards towards the head, than in the reptiles or the warm-blooded vertebrata. Meckel observed the deep separation of the two auricles in the *siren* and in the *axolotl*, and their difference of size and position, without perceiving the difference of their function, which has been pointed out by Weber, but the latter eminent anatomist has accompanied the announcement of his discoveries with remarks which, as applied to the profoundest anatomist Germany has ever produced, will not enhance their value in the estimation of foreigners. In the ventricle of the *pipa*, Meckel discovered a septum extending forwards from the apex for about two-thirds of the length of the cavity, which he compares to that seen in the chelonia, and although he was not acquainted with the observations of Dr. Davy, he perceived in this animal a deep partition dividing the auricle into two halves.

Looking at the heart of the American frog (*Fig.* 173) from behind, we perceive in these plates of Weber the great trunk of the inferior cava (*Fig.* 173, *c*), and the two superior cavæ (*Fig.* 173, *a a*), forming a small sinus venosus (*Fig.* 173, *d*) before they open into the large right auricle (*Fig.* 173, *e e*). The two pulmonary veins (*Fig.* 173, *h h*) returning from the cellular lungs (*Fig.* 174, *i i*) unite into a single trunk (*Fig.* 173, *g*), before entering the small left auricle (*Fig.* 173, *f*). Both auricles contracting at the same time, their contents are conveyed into the thick white ventricle (*Fig.* 173, *k*), which propels this mixed fluid into the thick bulbous origin of the great systematic trunk which gives off the two pulmonary arteries, the two trunks to the anterior portion of the body, and the two arches of the abdominal aorta.

Fig. 173

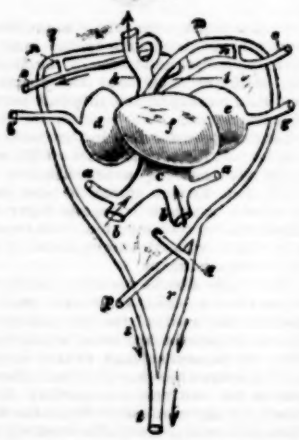
In the reptiles, the whole sanguiferous system is advanced to a higher stage of development than we find in the amphibia, or in the fishes, and this superiority is chiefly marked in the pulmonic portion of that system. Both auricles are more muscular, more distinct, and are more advanced to the anterior part of the ventricle. The heart is farther back from the head, and the left auricle is now more obviously separate from the right and larger than in the amphibia, to correspond with the increased development of the air-breathing organs.

The right auricle receives directly the venous blood, which is brought from all parts of the system; the left auricle receives the arterialized blood which comes from the capacious lungs, so that we have here developed more equally than in the amphibia the two auricular cavities of the heart, having here totally different functions from each other, besides the ventricle that we have traced up from the crustacea. We see in the ophidian reptiles the septum already developed to a great extent from the apex of the ventricle through its cavity, so that the two divisions of that cavity communicate only by an aperture towards the base of the ventricle. There are yet only semilunar folds to protect the two orifices from the auricles into the

ventricles, and there are semilunar valves at the openings of the aorta and the pulmonary artery. The aorta divides generally into two principal trunks, the one forming the left descending abdominal trunk, and the other, after giving off a large vessel for the anterior parts of the body, descends to form the right branch of the abdominal aorta, as we see in the chelonian reptiles. The heart even of the serpents partakes of the lengthened form of the body, especially the auricles, as you observe represented by Weber in these plates of the heart of a *coluber*. The form of the auricles is less lengthened in the lizards, and their parietes appear more muscular, but the general structure of the cavities of the heart, and the mode of distribution of the great bloodvessels, are nearly the same as in the serpents. From the manner in which the great pulmonic and systemic trunks are connected together by cellular substance, and enveloped by the pericardium on issuing from the ventricle, they appear externally as if they composed a single thick aortal trunk, till they escape from the pericardium, and separate for their respective destinations.

The broad heart of the chelonian reptiles (*Fig.* 174, *d e f*) corresponds with the great

Fig. 174



transverse development of their body, and it has a close analogy to the broad form of the auricle and ventricle in the highest of the cartilaginous fishes. The two wide posterior *venæ cavæ* (*Fig.* 174, *b b*) generally receive the two smaller anterior *cavæ* (*Fig.* 174, *a a*) before they unite to form a *sinus venosus* (*Fig.* 174, *c*), which pours the venous blood of the whole system into the *right auricle* (*Fig.* 174, *d*). The two pulmonary veins (*Fig.* 174, *g g*) return the arterialized blood from the capacious and cellular lungs directly into a large muscular *left auricle* (*Fig.* 174, *e*), and the two auricles contracting, as in other animals, at the same time, convey the two kinds of blood, by distinct orifices into the same large, thick, broad, and depressed ventricle (*Fig.* 174, *f*). The partition of the auricles extends inwards, and forms a broad membranous valvular fold over the two orifices of the auricles in the ventricle, which forces the two currents of blood to take opposite directions on entering the ventricle.

The great systemic aorta is divided into two trunks (*Fig.* 174, *h m*) from its origin, the first of which is the smaller, and, proceeding to the left side, forms the *left* trunk of the *abdominal aorta* (*Fig.* 174, *m*), giving off the large *cœliac* (*Fig.* 174, *p*) and *mesenteric* (*Fig.* 174, *q*) arteries, before it unites by its *communicating branch* (*Fig.* 174, *r*) with the *right* branch of the *abdominal aorta* (*Fig.* 174, *s*). The second branch of the great systemic artery coming from this single ventricle, divides into two branches, the one forming the right branch of the abdominal aorta (*Fig.* 174, *n s*), and the other forming the common trunk of the brachial and carotid arteries of both sides of the body (*Fig.* 174, *k*). The two pulmonary arteries (*Fig.* 174, *o o*) arise by a single wide bulbous trunk (*Fig.* 174, *i*), behind a large muscular fold in the right portion of the ventricle, which fold Meckel compares to the strong muscular fold forming the tricuspid valve in the right ventricle of birds. This broad membranous band, extending laterally from the free edge of the septum of the auricles into the ventricle, so conspicuous and large in the chelonia, is seen also in the ventricle of the serpents, the lizards, and the crocodiles. It projects laterally to a less extent in the ventricle of these reptiles, and forms a thin semilunar fold, or valve, over the orifice of each of the two auricles. Now Weber has found a small opening of communication through the septum of the ventricles of the *crocodiles*, in the usual position near the base of the ventricle, as in serpents and lizards, although Meckel, Martin Saint-Ange, and many others, have given to these large cold-blooded reptiles, two ventricles completely separated from each other by an impervious septum, as in the heart of a bird or a quadruped. There is but one ligamentous band left in the crocodile connecting the apex of the ventricle to the pericardium, and in higher classes even this is lost. You will observe, that the

venous blood returned from all parts of the system in the crocodile, is conveyed into the right auricle, from which it passes into the corresponding portion of the ventricle; from the ventricle it is propelled into those great trunks that come off from the base of the heart; those are the one conveying venous blood on each side to the lungs, and having its commencement of an enlarged form, like a bulbus arteriosus; the other portion coming off from the ventricle, divides in this figure of Cuvier into three principal trunks, the one upon the right side is observed to give off the right descending aorta, and the right arteria innominata, and which arteria innominata divides into the common carotid, the vertebral, and the great axillary arteries; the second trunk is the arteria innominata on the left side, which rises directly upwards, and divides in the same manner as on the left side; the third branch of this great aortal trunk is the left descending aorta, which unites with the right aorta in the crocodile, before it has given off any of those great trunks that we usually find given off by the left descending aorta in reptiles. That appears to depend on the advanced position or suddenness of this union, and upon the lengthened form of the trunk of the crocodile compared, for example, with the trunk of the tortoise. This single trunk, formed by the junction of the two descending aortæ, as in the greater number of reptiles, gives off the cœliac, the mesenteric, and the other branches of the abdominal aorta. According to Meckel, the circulation in the *crocodilus luceus* is somewhat different. We observe that there comes off here, according to him, from the first right branch of the great aortal trunk, the right descending aorta, and the right subclavian; those two vessels alone. The second branch of this great primary trunk gives off the left subclavian, the two carotids, and the vertebrals; then the third, as before, constitutes the left descending aorta. You will observe, that near the place where the bulbus arteriosus divides into the two pulmonary arteries, and at a little distance on either side, from the bifurcation of those arteries, there are two venous canals which descend one from each pulmonary artery, and unite with the two branches of the descending aorta; this is the ductus arteriosus upon each side. There are two ductus arteriosi in reptiles; there are two also at first in birds.

In the chelonian reptiles the general structure with regard to the cavities of the heart is the same nearly as in the saurian reptiles. The venous blood is conveyed by two superior and two inferior venæ cavæ into the right auricle, where there are two semilunar valves, and from that into the single ventricle. The arterialized blood from the lungs is conveyed by a very oblique entrance into the left auricle, which has no protecting valves, and from that into the same partially divided ventricle of the heart. From this ventricle there comes off what appears upon opening the animal to be a single vessel, but upon dissection it is found distinctly to consist of two principal trunks, one forming a bulbous enlargement, which is the commencement of the two pulmonary arteries, the other trunk subdividing gives off upon the right side the right descending aorta, and gives off a great trunk (*Fig.* 174 *h*) to the anterior part of the body which subdivides into the subclavian, and the common carotid arteries upon both sides; the other trunk is the left descending aorta, which gives off the cœliac artery and a single mesenteric, the superior mesenteric artery, thus diminished in its caliber it forms the ductus communicans, which is only a continuation of the left descending aorta into the great right trunk of the abdominal aorta.

We observe coming off again from those two pulmonary arteries a ductus arteriosus (*Fig.* 174 *n n*) upon each side; the ductus arteriosus here is not only present on both sides, but we observe it to continue to a late period upon each side. I have found them present, though impervious, in a full-grown large Indian tortoise. I found both the *ductus arteriosi* large and strong in that old animal, although they had become impervious cords.

Thus we observe that in the chelonian reptiles there is a considerable difference in the outward form of the heart. The heart has here a flattened depressed form, and its ventricle especially is much extended transversely; that corresponds very much with the form of the heart which you perceive in the sharks and rays. In the sharks you will observe also, as in these reptiles, that the auricle is raised considerably above the back part of the ventricle, the bulbus arteriosus having in these cartilaginous fishes a lengthened cylindrical form. You will observe that in the tortoise the form of the heart externally corresponds pretty much with that of these highest of the cartilaginous fishes. When we open this ventricle in the chelonian reptiles, we observe that it gives origin to different arterial vessels; the blood which is returning arterialized from the lungs by the left auricle of the heart comes in from the left side of the valvular continuation of the septum auricularum, of considerable breadth in these chelonia, which is placed between the two

openings of the auricles, and hangs over by its free margin the orifices of both those auricles. Here the blood passes through a very loose spongy texture in the left portion of the ventricle of the heart which is formed by the numerous fleshy columns and chords that are remarkably loose and detached in this region of the heart. The venous blood which is brought from all parts of the system by the right auricle of the heart is conveyed into the ventricle through the other oblique opening on the right side of this great membranous valve. Besides this valve which hangs over both the entrances of these auricles, each auricular orifice is provided with another opposite distinct valvular fold, so that they have ample means of closing up the apertures. Now in the contraction of the ventricle, the opening of the right auricle appears to be brought nearer to the opening of the pulmonary arteries than the opening of the left auricle, thus the dark-coloured venous blood passes more easily into this right pulmonic portion of the ventricle than the arterialized blood, which gets more readily into the great systemic aortal trunks.

In the class of birds we have at length fully perfected that condition of the circulating system which belongs to the hot-blooded classes of vertebrata. They have a vigorous and active sanguiferous system, which corresponds with the increased energy of all their functions, the high temperature of their body, and with the great muscular force which we see exerted by those animals. The air is admitted into contact with the systemic capillaries and the circulating fluid in most parts of the body—in the interior of the bones, in the large cells which extend to the surface of the body, which fill the cavity of the abdomen, and which extend in every direction from the lungs. There is a great development of the superficial vessels in birds which corresponds with the development of their superficial parts, and with the great power of their muscular action. We observe, that when their muscular action is much exerted, the effect of the compression of the deeper-seated vessels is to accumulate blood in the less-pressed-upon superficial vessels, and to determine thus the blood, the source of all development, largely to the surface; their surface-temperature is raised to enable them to hatch their eggs, perspiration is copiously thrown out to cool their heated body, their down and plumage are developed to equalize their temperature, and various other important results follow from this increased vascularity of the surface in birds and in almost all hot-blooded vertebrata.

The venous blood from all the anterior and posterior parts of birds is conveyed by one posterior and two anterior venæ cavæ into the right auricle, by which it is sent into the right ventricle of the heart; and it is prevented from returning into the right auricle by means of a strong muscular valve, which you here observe in the position of the tricuspid valve of quadrupeds. It is the only valve which we observe in that situation; it is placed over the right auriculo-ventricular orifice.

The blood is propelled from the right ventricle of the heart, now completely separated from the left by an impervious septum, through the two pulmonary arteries. The pulmonary arteries in birds communicate at an early period with the two great branches of the aorta by means of a ductus arteriosus upon each side. The first of those ductus arteriosi obliterated in birds is the one upon the right side; the one that remains latest is that on the left side; and that in the mammalia which we observe alone developed in the later periods of the fœtal condition is that upon the left side. The blood which has been aerated in the lungs is conveyed through the left auricle, now as large as the right, to the left ventricle, and from them it is propelled into the aorta, which subdivides near to its origin into two and sometimes into three principal trunks. We observe upon the right side the first branch given off from this aortal trunk is the large trunk formed by the descending abdominal aorta and the branch which corresponds with the right arteria innominata which gives off the common carotid, the vertebral, the axillary, and the thoracic arteries to be distributed upon the enormous pectoral muscles and other parts of the breast. The second branch given off from this great aortal trunk in birds is the arteria innominata on the left side which gives off the common carotid, the vertebral, and thoracic branches of that side. Tracing downwards the abdominal aorta we observe, after the œsophageal arteries and the intercostals, that it early gives off a large cœliac artery, which divides into numerous branches, and a superior mesenteric, as we saw in most reptiles, which is distributed on the whole intestine; then it gives off the upper renal and the spermatic arteries.

The cœliac artery in birds generally gives a branch to the œsophagus, another the gastric to the ventriculus succenturiatus and the gizzard, the splenic, the hepatic, and a branch to the two cæcaeoli. The iliac arteries come off very high in birds from the forward attachment of the legs, so that the aorta continues for a great distance along the lengthened sacrum,

as the middle sacral artery, still giving off numerous important branches in its course. The muscular coat of the arteries is stronger even than in quadrupeds, and the valves are more numerous in the veins. The pulmonary artery issuing from the right ventricle has thin soft parietes compared with those of the aorta, and divides very near to its origin into a right and left pulmonic branch. The pulmonary veins collect into one trunk from each lung, and these two trunks generally meet so as to enter the left auricle by a single orifice. The renal venous circulation pointed out by JACOBSON in birds is questioned by MECKEL, from the direction of the valvular folds at the junction of the anastomosing veins. The femoral veins unite into a single trunk at the anterior extremity of the kidneys. The hepatic venous or portal circulation is here more extensive than in the inferior vertebrated classes. The caudal, the renal, and the femoral veins here unite, and enter the vena portæ to be distributed with the venous blood from the chylopoietic organs through the liver.

It is in the class of quadrupeds and in the human body that we find all parts of this complicated hydraulic apparatus for the conveyance of the vital fluid to every portion of the system the most exquisitely elaborated and arrived at its maximum of development, but the general plan in this highest warm-blooded class is similar to that presented by the feathered tribe. Innumerble interesting modifications, however, of this complex system are met with in the subdivisions of this extensive and varied class, depending on differences in the structure of internal parts, or in the outward form of the body, or on peculiarities in the living habits of species. The thick fleshy fold in the right ventricle of the birds is here supplied by a more delicately-constructed and more complicated cricuspid valve, beautifully adjusted for its object. The coats of the arteries are more distinct, and all the valvular apparatus of this sanguiferous system are more highly finished than in the inferior classes.

In the lowest mammalia, the cetaceous animals, we observe the heart to have generally that depressed and flattened form which it presents to a greater degree in the cartilaginous fishes and in the chelonia. We observe in the dugong not only this flattened form, but that the heart presents at the apex between the two ventricles a cleft appearance. In fact this is a remnant of the original more complete separation of those two cavities which we observe to be formed originally from one cavity cleft into two by a septum which draws it up in the middle. Those two portions of the divided heart unite into a single mass by the addition of new fibres externally in higher mammalia; but here they retain permanently their original state of separation. This structure is met with in all the herbivorous cetaceous animals. We observe in the dolphins numerous plexuses of the distended intercostal arteries in the interior of the chest, and enveloping the bodies of the vertebræ, which complicated plexuses form an immense accumulation of arterial blood-vessels lining the whole dorsal part of the cavity of the chest. This structure has been thought partly to retard the blood in those vessels for the formation of the subcutaneous adipose substance thrown out so largely upon the surface of the muscular system. It has been thought to be accumulated in the region of the spine, where it envelops the spinal marrow also within the canal of the vertebral column, in order to prevent the influence of cold upon the spinal marrow, which we know to be so deleterious, and to affect the whole system so instantaneously when anything is applied to change or affect the temperature of that great centre of nervous energy. The cetaceous animals have no posterior extremities, and we observe that the trunk of the aorta, after giving off two small twigs to the pelvic region, continues its great trunk through those inferior spinous rings or foramina which are formed by the inferior laminæ or cata-vertebral elements attached below to the intervening spaces between the bodies of the vertebræ. The inferior vertebral canal thus protects what in higher animals is called the arteria sacra media; but here it is a large continuation of the aorta itself.

As we ascend through the orders of quadrupeds we observe gradually introduced all those ameliorations of the structure which characterize the human vascular system. We see in the long-necked ruminating quadrupeds the blood sent down through the vessels of the pendent head, increasing in its velocity by the simple act of gravitation, the head being extended towards the ground, while in the animals like the giraffe, with their heads habitually raised upwards, the condition is reversed. The blood in such grazing quadrupeds sent through the internal carotids, when it reaches the sides of the cella turcica, is sent into numerous anastomosing branches, and those ramify and form numerous plexuses, that tend much to retard the impetus of the blood before it is distributed even on the surface of the brain, or passes into the interior of that delicate organ. The vertebral arteries have always a very tortuous form at their entrance into the cranium, to be distributed upon the delicate brain; but it is re-

markable that in the rodent quadrupeds we have a distribution of those vertebral arteries that is analogous to what we commonly see in birds, where in place of passing into the cranium to unite to form the basilar artery, and so by communicating with the internal carotid to form the circle of Willis and to be distributed upon the brain, they pass out to anastomose with the occipital arteries, and to be distributed not upon the brain, but upon the exterior of the skull. In birds, as in *rodentia*, this is observed. It occasions a development upon the exterior parts of the head that here require a higher degree of development than the internal parts. We perceive the influence of this peculiar distribution of the nutritious element the blood, which we might imagine should be sent into the brain in order to develop that important organ; but it retards the development of the cerebral hemispheres in the birds, and keeps them in that comparatively small and embryo state which they are found in; and the short smooth convolutionless cerebral hemispheres in the rodentia are remarkable among the quadrupeds for their inferior size and their embryo type, and their analogy in this respect with birds.

We see a considerable distance to intervene in carnivorous and many other powerful quadrupeds between the passage of the inferior cava through the diaphragm and its entrance into the right auricle, so that their heart is comparatively free in the chest. The strong muscular diaphragm in these active carnivorous quadrupeds, which is remarkable for its muscularity, strength, and mobility, does not materially interrupt the action of the heart or disturb the circulation by its violent movements.

The seals and the beavers and the other diving quadrupeds were thought to retain through life the fœtal condition of their circulating system, that the blood unchanged by respiration might continue to circulate freely through their body when respiration is suspended; but not one of all these quadrupeds is found to have either the foramen ovale or the ductus arteriosus permanently open; their sanguiferous system is still that of a quadruped and not of a reptile in their mature condition, which, however, they are later in assuming. Their inferior cava is enlarged and dilatable to form a sinus for the accumulating and interrupted blood, as we see in animals of other classes but with similar habits, in diving birds, in turtles, and in predaceous fishes.

The large right lung of the mole pushes the heart from the median line to the left side, and this sinistral position of the heart, and its proximity and attachment by means of the pericardium to the diaphragm, become more general and more marked characters as we ascend through the monkeys and the orangs to man. In most of the carnivorous quadrupeds, in many of the rodentia, quadrumana, marsupialia, edentata, and in the monotrema, animals which make much and free use of their arms, especially for prehensile purposes, transmit their brachial or their ulnar artery through an osseous canal above the inner condyle of the humerus to protect it from pressure. In the marsupial quadrupeds the great development of the epigastric arteries to supply the mammæ and the pouch robs the hypogastric and uterine arteries of the means of maturing a fœtus, and renders an early abortion a normal and necessary character in these animals.

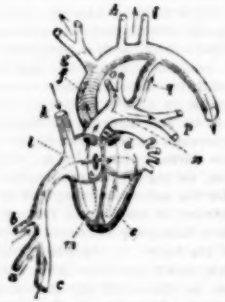
There is generally but one great artery ascending from the arch of the aorta in the ruminantia and solidungulous pachyderma, which divides into two unequal branches. The right branch divides into the right subclavian and the trunk of the two common carotids which are soon given off. The left branch is the left subclavian. But in the carnivora, and most other quadrupeds, this left subclavian artery comes off separately from the ascending aorta, making two branches the most frequent number proceeding directly from this great systemic vessel to supply the anterior parts of the body. The ornithorhyncus and the sloths, and some others of the lower quadrupeds, are found to resemble man and several of the quadrumana, in having three branches arising from the ascending aorta.

The parts supplied by the descending aorta are more constant in their characters than those nourished by the branches coming from the ascending portion, and we find a corresponding regularity in the arteries, which vary little from the arrangement presented by the human body. It gives off the small bronchial and œsophageal, a variable number of intercostal and lumbar arteries, and in the abdomen the diaphragmatic, before we arrive at the origin of the great cœliac artery, and the superior mesenteric, which often arises from the same trunk as the cœliac. The supra-renal, the renal, and the spermatic vessels, are sent off a little above the inferior mesenteric artery, below which it divides into the two iliacs, and the caudal artery, the most variable in magnitude, is continued along the middle of the sacrum. The portal circulation in the mammalia is more complete and isolated than in all the inferior vertebrated classes. The ornithorhyncus has the fleshy tricuspid valve

of a bird, and like the birds it has two superior venæ cavæ, and one inferior, all protected by valves. In the lowest cetacea, as in the highest of the quadrumana and man, the pericardium closely connects the heart to the surface of the diaphragm. In the sloths, and some other slow-moving quadrupeds, the trunks of the humeral and femoral arteries give off numerous branches at their origins, which follow them in their course, and again unite with them to compose the usual arteries of the fore-arm and the leg—a peculiarity which seems to be connected, by its retarding the flow of the blood, with the slow movements and the durable reptile grasp of their members. But every tribe and every species of sanguiferous animal presents modifications of this important system adapted to its condition and its wants.

Now these various grades of development, through which we have passed in tracing the forms of the sanguiferous system throughout the animal kingdom, are faithfully imitated and repeated in the successive transient forms which this system presents during the development of all the higher animals and man. The globules, still colourless in the central part of the germinal membrane of the ovum, are attracted and repelled, and move freely in two contiguous circles like the circulation of the lowest annelides. These globules arrange themselves to form veins and trunks and arteries, and the circulation is then conducted in closed vessels, as in the radiated and several of the articulated classes, without the aid of a heart. The centre of this system becomes the pulsating, dorsal, heart-forming vessel, and the branches are the vessels of the yolk-bag. The punctum saliens forms a ventricle which develops an auricle behind it, and a bulbus arteriosus before it. Beyond this bulb the aorta divides into five pairs of branchial arteries, and the branchial openings are seen on the side of the human neck. These branchial openings have been found to remain open through life, forming congenital fistulæ in the human neck. The auricle is gradually doubled up upon the ventricle, and takes its position above that cavity as in the highest fishes, the branchial arteries are successively converted into the systemic branches of the arch of the aorta as during the metamorphosis of a frog, and a septum rises through the auricle. So that man's vascular system, when with only a pulsating vessel along the back, is that of an insect, and when the ventricle is developed, it becomes that of the highest crustacea. With an auricle and a ventricle placed in a line, it becomes that of a molluscous animal, and with a superadded bulbus arteriosus and an advanced auricle, it is converted into that of a fish. The development of a second auricle by the septum rising through the first, and the metamorphosis of the anterior branchial arteries into systemic vessels, and the posterior pair of branchial arteries into pulmonic trunks, raises this system in the developing human embryo to that of a reptile. The septum of the ventricles appears to be completed before that of the auricles in man, and the reptile circulation is continued for a time by a different route. The aerated blood of the placenta is sent at this period through the umbilical vein, the ductus venosus (*Fig.* 175, *a*), the inferior cava, and the right auricle (*Fig.* 175, *l*), directly to the foramen ovale, by which it is transmitted to the left auricle (*Fig.* 175, *d*), the left ventricle (*Fig.* 175, *e*), and the ascending branches (*Fig.* 175, *g*, *h*, *i*) of the arch of the aorta, to nourish and develop the brain, the organs of sense, and all the important anterior parts of the body so large in the fœtus, while the diminutive posterior parts are chiefly supplied with venous blood, which has already passed through the upper parts of the body. This impure blood returning by the superior vena cava (*Fig.* 175, *k*) from the largely developed head and arms, is sent through the right auricle (*Fig.* 175, *l*) directly into the right ventricle (*Fig.* 175, *m*), which propels it through the ductus arteriosus (*Fig.* 175, *q*), and the descending aorta, to give a scanty nourishment to the limbs, and to proceed through the umbilical arteries for fresh aeration in the placenta. The ascending septum of the ventricle draws up the apex of the human embryo's heart, and makes it double, like that preserved through life in the lamantin and the dugong, and this septum, on reaching to the origin of the still single sys-

Fig. 175



temic artery, divides it to the extent of the ductus arteriosus, and entirely severs that portion from the original bulb of the aorta. But it is only by the closing of the umbilical arteries and vein, and of the ductus venosus, the foramen ovale, and the ductus arteriosus, that man's circulating system is raised to the mammiferous type, after a proteus-like career through every inferior form presented by the animal kingdom.

LECTURE L.

ON THE RESPIRATORY ORGANS OF THE INVERTEBRATED ANIMALS.

The function of respiration is one of the most general in the animal kingdom. Almost every animal has the power of renewing the stratum of the surrounding element in contact with its external or its internal surface, either by moving its body to and fro, or by creating currents in the medium in which it lives, to aerate the fluids of its interior. The monad excites currents in the water around it, to aerate its surface, by the rapid vibration of its cilia, as man produces currents in the air for the same purpose, by the alternate motions of his ribs. The object of respiration being merely to oxygenate the fluids of the body, to renovate their vital properties, and to prepare them for their functions in the economy by exposing these fluids to the influence of atmospheric air, either in a pure state or as contained in water, it is obvious that it may be performed through the medium of any soft or membranous portion of the body, as the general surface of the skin or intestine, without having any organ specially appropriated to it. Indeed, in the lowest tribes of animals, the general surface of the body is the only part through which the atmospheric influence is received, and the skin is obviously the origin of most forms of the respiratory organs. The gills of aquatic animals, and the pulmonic cavities of the invertebrated tribes opening on the sides of their body, are but extensions of the general integument over which the blood is more or less distributed; and the complicated lungs of the highest classes are but internal developments of the skin, or of its continuation the alimentary canal. Although there is no special organ appropriated to respiration in the lowest animals, and this function is performed by the simplest means in the highest classes, it is one of the most important and indispensable in all animals. It restores the lost properties of the fluids, it gives activity to all the organs and increased energy to all the functions, it is the source of animal heat and the principal stimulus to development in all classes.

The respiration of the polygastric animalcules is effected by the rapid vibration of the cilia variously disposed on their surface, by the motions of which they are transported through the water, and the soft cellular substance of their body is thus aerated through the thin pellicle which covers it. These minute vibratile filaments, here serving as organs of motion, are thus early connected with the function of respiration, and we find them to form a part of the respiratory apparatus of all the higher aquatic invertebrata, and even in the vertebrated classes. These cilia are generally shaped like the component laminæ of the gills of fishes, having a lengthened, flat, thin, and tapering form, but they are not the analogues of these laminæ, and they do not appear to be designed to afford a surface for the distribution of capillary vessels. They continually renew the stratum of water in contact with the surface on which they are placed. Their motions are generally so rapid that they are only seen during their motion forward, their stroke to impel the water, and being visible only in this slower motion, they appear to the eye to move always in the same direction. From the extent and width of the alimentary canal of these animals, and the numerous cavities which open into it and which are often seen distended with water, their respiration may in part be effected by their internal as well as their external surface; and where the structure is so simple and the functions so few, this extensive respiration must contribute to their great and continued activity, to their rapid development, and the extraordinary fertility of their races. Thus we perceive that this important function is effected in them without the aid of branchiæ or lungs of any kind, and simply through the skin or its continuation inwards, the alimentary canal, as we find in the embryo state of the highest animals. Their cilia are merely the organs by which the stratum of water in contact with their surface is rapidly and incessantly renewed; they are the organs by which they swim to and fro in the water; the organs, consequently, which are useful to them in pursuing their prey and obtaining their food. Their simple organization required no other respiratory system. Their bodies are not yet covered with solid shells, or with dense impervious scales, or with other hard materials which would exclude the general respiratory influence of water, and necessitate the formation of gills or lungs; but consist merely of the soft cellular tissue in which all higher organizations are first developed.

Sometimes they are sheathed in a thin transparent horny pellicle, from which the ciliated and prehensile portion of their body is capable of being extended, and consequently of effecting all the required respiration. These loricated animalcules are much fewer than those which have the whole surface of the body naked, and which have, consequently, the freest means of respiration.

In describing the organs of the circulation, I mentioned that a reticulated vascular appearance was observed over the surface of the body of these polygastric naked animalcules through the aid of a microscope, in which vascular plexus there appeared to be a motion of fluids without the least appearance of contraction or motion of those capillary vessels themselves. This is the best position for them to occupy, it is almost the only position in their body in which the blood could be placed to come nearly into contact with the surrounding element, and thus to be prepared for the nourishment of the system in those simple animalcules, where there are no special tubes or distinct cavities for conveying that medium freely through the system. The structure and forms of those minute cilia, and their regular though varied disposition over the surface of the body, I have already had occasion to speak of in describing the organs of motion. Sometimes we cannot, from their extreme minuteness, determine the regularity of this disposition. We find them generally larger at the anterior part of the body, often surrounding the entrance of the alimentary canal, and often regularly disposed in longitudinal series over the surface of the body, as we see often in the larger ciliograde acalephæ.

In the poriferous animals, although we can perceive neither cilia nor any other distinct apparatus, tending to convey a fresh stratum of water incessantly over the surface of their body and over the parietes of their internal canals, the slightest observation of those animals in the living state shows us the rapidity with which the water is actually renewed over the surface of their body and throughout the whole of their internal canals—the force with which it is drawn in through their internal pores, and the velocity with which it is conveyed through all their anastomosing internal canals, and incessantly thrown out by all the large orifices. The organs by which those respiratory currents are effected which are so obvious in all the living poriferous animals have not yet been observed, but from analogy it is very probable that they are effected by the same vibratile minute cilia disposed on the interior of their pores and canals, so as to direct the currents through them and the canals and orifices. From the regularity, the constancy, and smoothness, of these currents during the whole life of the poriferous animals, it is obvious that they are not by means of these currents snatching at animalcules, or drawing in the currents solely for the purpose of seizing some particular kind of food which they perceive or feel in contact with their surface. The motions are, as almost all movements produced by vibratile cilia, more like respiratory currents, or like some physical phenomena not depending on vitality; it is a continued stream, as regular as the motions of rivers from their source to the ocean, or any other movements depending on the established order of things. Now the effect of these currents is here again obviously to bring fresh strata of water in contact with the whole of the gelatinous surface of their body, and through the whole of the interior cavities of their canals, which are also lined by the same soft gelatinous or cellular substance. No apparatus for seizing animalcules, or food of any kind, is observed in the whole structure of their bodies. They approach nearer to the vegetable kingdom than any other known animals; and many eminent naturalists, as Blumenbach, regard them as vegetables. In their embryo state, or when in the condition of gemmules, we observe them moving about like the gemmules of zoophytes, moving to and fro by the action of distinct cilia, in search of a suitable place to fix up and develop. At this period we can perceive distinctly the successive movements of those cilia; we can easily see their shape and how they cause the little gemmules to move forward or to revolve on their axis; and from the distinct existence of those organs in the embryo state of the poriferous animals, it is the more probable that some similar apparatus for the production of the currents, and for the nourishment and respiration of the body, may continue, though not distinctly perceptible, through the whole of life. It is obvious that those currents, by occasioning constant fresh supplies of water in contact with the whole body, must contribute both to the nourishment and the aeration of those poriferous animals; so that their respiration, though not provided with a separate organ for its performance, is effected by every point of the exterior and interior of their body.

In the polypiferous animals the respiration is aquatic, and is performed by means of vibratile cilia, variously disposed on the polypi. The zoophytes may almost be regarded as porifera, with the margins of the pores extended out and developed into sacs with fimbriated margins;

and we observe those vibratile cilia are as rapid and constant in their motions as we find them around the mouth of many polygastric and rotiferous animalcules. They are often disposed around the orifice of the polypus, when the arms are not vibratile; most frequently upon the sides of the tentacula. They are disposed and moved in such a manner as that the streams which they produce in the surrounding water are driven along the one side of the tentaculum from the mouth of the polypus, and on the other side of the tentaculum always towards the mouth of the polypus. And we never find that direction of their motion reversed, or that direction of the currents changed, by which their respiration is effected and their food obtained. They are vibratile on the arms of most of the lower zoophytes, as *sertulariæ*, *plumulariæ*, *serialariæ*, *cellariæ*, *flustræ*,*alcyonia*, which keep their arms stiffly out in a regular campanulate form, while the currents flow to their mouth. When we watch the sides of the tentacula of those animals with attention, and by the aid of powerful glasses, we see the extreme rapidity of the movements, and the remarkable regularity of the form, disposition, and motions, of those singular vibratile bodies. From the number of them, exceeding sometimes 400,000,000 in a single animal, it is not probable that their extraordinary movements are the result of any spontaneous efforts of the animal, or are accompanied with any kind of perception or consciousness in these animals, which have never been found to present a single nerve in their bodies. The independent nature of the motion of those minute respiratory organs is observed when we cut off the tentacula altogether; and observe, that they still continue the rapid vibration of their cilia; and though severed from the polypus, the tentacula continue to move forward through the water; the severed tentaculum of a *flustra* is seen to swim through the water like a worm. The number of those organs varies much; there are eight in *serialaria lendigera* and in *plumularia falcata*, fourteen in *cellaria avicularia*, twenty-two in *flustra corbesia*. The effect of those motions of the cilia again is obviously to change the stratum of water constantly in contact with the most delicate fleshy parts of those zoophytes, with the highly organized soft irritable fleshy polypi. Thus they aerate the cellular texture of their body at the same time that they bring the animalcules their ordinary food within the grasp of the tentacula. Many zoophytes, as *lobulariæ*, *gorgoniæ*, *isis*, *corallium*, without vibratile cilia, are aerated over their whole exterior fleshy surface, and others, as *actiniæ*, *zoanthus*, draw large quantities of the surrounding water into their interior, so as greatly to extend their function of respiration.

In the acalepha, or the sea-nettles, the respiratory organs still present themselves in the form of vibratile cilia. On the surface of the ciliograde acalepha, vibratile cilia are formed of great magnitude, symmetrically disposed, in longitudinal series. Those cilia, when viewed with a powerful glass, are observed to be composed of parallel rays, slightly curved at their free extremities, and similar in their appearance to the rays that support the fins of fishes. There are in the *beroe pileus* some forty of these broad flat fin-like cilia in each of the longitudinal series: and of those longitudinal series there are eight along the surface of the body. Their motion is generally from the mouth, which is in the centre below, upwards towards the anus which is diagonally opposite; this direction, however, they can reverse at pleasure. When we watch the interior of those animals, we observe a constant revolution of fluids, in tubes within their bodies, without the least motion apparently in the tubes themselves to produce these currents within, a phenomenon which remarkably resembles in its whole appearance that which we see taking place in the cells of plants.

The rapid vibration of those cilia will tend obviously not only to move those ciliograde acalepha through the water, and thus serve as organs of progressive motion, but they will also be a means of bringing them towards their ordinary food, which appears to consist of minute crustacea floating in almost every drop of the sea. They will likewise have the effect of changing the stratum of the water in contact with the thin pellicle covering the surface of their soft body, and of thus aerating their whole cellular tissue. But, indeed, the whole body of these soft gelatinous animals is as a lung breathing the surrounding element.

We observe in many of those acalepha that there are air-sacs. In that group of acalepha which have been denominated hydrostatic by Cuvier, such as you observe in the *physalia*, this large air sac is not, however, like a pulmonic cavity, capable of drawing in atmospheric air, of expelling it again, and of thus aerating their internal fluids; but it more probably consists of a gaseous fluid due to the vital powers of these acalepha, or of air which they abstract from the water, and which is designed to enable them to swim upon the surface of the water, where their food is most abundant, and where the atmospheric air is diffused in the greatest

abundance through the water to aerate their whole surface. They are capable of expelling this gas in part, and of compressing it, and thereby of rendering their bodies specifically heavier, so as to permit them to sink in the water. It does not appear consistent with analogy to suppose that these air-sacs, belonging to animals so low in the scale, are capable of being filled at pleasure with atmospheric air, and of being again expelled, as if these soft gelatinous, muscleless, nerveless, and almost motionless animals, already possessed large respiratory lungs like a vertebrated animal. In several medusæ, sacs are seen opening externally, and separated by thin septa from the cavities of the stomach, which appear destined to extend the respiratory surface of these animals, but their greatest respiration is around the margin of the mantle where they are most vascular.

In the echinoderma we observe more distinct and complex forms of the respiratory apparatus. In the asterias, the upper surface of the body we find to be covered, in the living state, with very minute transparent fleshy tubes, which rise and sink incessantly. They somewhat resemble in their form, though they are extremely minute when compared with them, those large inferior fleshy tubes, the organs of motion—the arms—that extend from the ambulacra at the lower part and middle groove of the rays of the asterias, which are the muscular and prehensile feet by which they are moved to and fro. Those organs on the upper surface of the body appear to be incessantly occupied in conveying water into the interior. In the interior this water is conveyed by membranous canals which are observed in contact with the vascular system, and it is propelled into those large inferior muscular and tubular feet to enable them thus to be forced out from the surface of those ambulacra. It is a mechanism by which we see the feet of most of the echinoderma, like the tubular tentacula of actiniæ, to be extended from the surface of the body, by the injection of water into them. Now these respiratory organs of the asterias were very accurately described by Reaumur more than a hundred years ago, both their structure and their uses.

In the echinida we often perceive similar small tubular fleshy organs, not adapted for locomotion, which appear to inhale water for the aeration of the blood, and this water is always found in large quantity between the shell of these animals and the contained digestive and generative organs.

The most complicated and distinct form of the respiratory system seen in the echinoderma, is that internal ramified form which we see in the holothuria, in that lengthened soft fleshy echinodermatous animal, with five longitudinal series of fleshy tubular feet, extending from the sides of its body, arranged like the cilia of a beroe. We have here exposed to view, at the posterior end of the body, the cloaca of the holothuria, into which the intestine opens, which intestine you observe throughout its whole extent filled with sand. Extending upwards through the abdomen from the right side of this cloaca, you will observe a short wide canal, which immediately divides into two principal trunks, then ramifies and subdivides into a series of beautiful and minute capillary vessels. Those are ramified water tubes, internal branchiæ, on which the bloodvessels from the intestine are distributed before they unite into the great systemic trunks to supply the body. They are the respiratory organs of the holothuria, and are situate between the venous blood and the arterial trunks of the system. This form of the respiratory organs is interesting in the holothuria, where you observe the water is not taken in by the mouth for respiration, but by the opposite extremity of the body, and a similar position of the branchiæ is seen in the bonellia. Upon these facts Geoff. St.-Hilaire has laid some stress in attempting to explain the use of those two openings that lead into the cavity of the peritoneum in crocodiles, as well as in many cartilaginous and osseous fishes, where he has conceived them adapted for an aquatic respiration, while these animals are struggling with their prey under water, as we have distinctly in these echinoderma an aquatic respiration performed solely through the cloaca. He has extended these views regarding the abdominal respiration of vertebrated animals to some of the mammalia, as the marsupial animals and the monotrema. The function of these ramified anal sacs of the *holothuria* is questioned by Chiaje, who could not find any connexion between them and the vascular system, and who regarded the tubular feet and the ramose tentacula as the true respiratory organs, but I have observed the large *holothuria pentactes* from the Frith of Forth often distend its body to five or six times its size when contracted, by inhaling water through the anus, and squirt that water again from the same aperture to a great distance from the vessel in which it was kept.

In the entozoa, the lowest of the articulated classes, we have animals which have no necessity for exterior protecting hard coverings, and where indeed a co-

vering of hard shells or scales would be a great inconvenience by impeding their motions in gliding through the soft textures of the bodies in which they feed. The softness of the cutaneous surface which they more required and which they possess, is sufficient to allow their circulating fluid to be oxygenated by the fluids of the animals in which they live, like a fœtus in utero. Their circulating fluid is thus oxygenated, and their temperature likewise is raised, and depends on the soft parts of the animals in which they reside. No branchiæ nor internal sacs for respiration have been detected in any animals of this class. We know that their circulating system is distinct and highly developed, particularly in those more complex forms that are found attached to the outer surface of the body. In the entozoa the circulating system is confined to vessels, and these are chiefly distributed near the surface of the body, where they are most exposed to be aerated through the thin skin.

In the rotiferous animals, though highly developed in most of their organs, no branchiæ have been discovered; but we observe, as in many aquatic animals beneath them in the scale, that the surface of the anterior part of their body presents numerous active vibratile cilia, disposed generally in circles,—these are the wheel-animalcules. Those vibratile cilia have here great size and strength, are moved by powerful muscles, and they have ligaments also, by which they are attached to the anterior part of the body. Those are the organs of respiration as well as of progressive motion. Those animals possess a circulating system, consisting of vessels distributed near the surface of their thin transparent skin, and it is probable that the rapid action of the vibratile cilia, besides enabling them to pursue their prey, to move to and fro in the water, serve to aerate their blood. Their capacious abdominal cavity appears generally distended with pure water, and a vibration of small cilia has been observed by Ehrenberg, both on the peritoneal surface of the intestine and in its interior, which may contribute to aerate the fluids in the wheel-animalcules where there are no gills.

In the cirrhopods we observe, however, distinct gills, which vary in their number in the different species. The two laminated pyramidal organs attached to the bases of the two proximal pairs of those ciliated cirrhi, which you perceive extending from the posterior part of the body in these specimens of *anatifa*, present a somewhat different form from the rest of the feet, being short, thick, less curved, and of a lighter colour. You will see them very well in the specimens I now send round, in which I have drawn out a little the cirrhi, and removed the shell from one side of the body. Those are the two pairs of branchiæ of the *anatifa*, which in some cirrhopods much exceed that number. They extend from the sides of the mouth, like the lips of a bivalve, or the arms of a brachiopod, but they are gills formed like those of crustacea, and similarly attached. The long curled feet which these animals are constantly extending and retracting, have been supposed to be also respiratory organs.

The respiratory organs of the red-blooded worms are interesting from the variety of forms which they present. We find some of them to be organized for breathing atmospheric air, by means of numerous pulmonic sacs, and others for breathing only through the medium of water. Those water-breathing annelides which are confined in tubes, whether of sand or of agglutinated particles of shells, or in calcareous tubes, which they exude in one piece from the surface of their body, can only have their branchiæ disposed on the anterior part of their body and their head, which is generally kept extended from the tube. Those are the cephalobranchiæ or the tubiculous annelides of Cuvier. It is the position in which the branchiæ, in the form of beautiful plumose tufts, are most exposed to the surrounding element in animals that reside in tubes, like these *terebellæ* and *pectinariæ*. They are not in the form of those ciliated pyramidal branchial organs which you see in the enclosed testaceous cirrhopods, but they are here generally straight and plumose, and beautifully radiating from a centre to form a fan-like expansion around the head. Their symmetrical and ciliated gills are beautiful from the brilliant hues they display when we watch them in the living state in sea-water, through the aid of a magnifying glass. In other annelides, as in the common sand-worms, the *arenicola piscatorum*, the branchiæ are in the form of large ramified tufts, confined to the middle part of the back; they are seen extending in a row of thirteen upon each side of the dorsal part of the body. The blood being here of a red colour, and all the parts perfectly transparent in those ramified tufts, produces a beautiful appearance in the living state, when they shoot up and sink down by the impulsion of the red blood into them by the great vessels of the trunk. That contrast of lively colours and transparent parts presents a beautiful appearance in these red-blooded worms when seen through a glass vessel, filled with pure sea-water. In

others, again, as in the *pleione*, the branchiæ are disposed in regular ramified tufts along the whole extent of the back, from the anterior to the posterior part of the body accompanying the dorsal or upper lateral rows of feet. They have a similar ramified structure, however, to those of the *arenicola*. In the common sea-mouse, the aphrodita, or the *halithea aculeata* of Lamarck, there are very small respiratory tufts at the bases of the upper rows of feet, and the larger branchiæ in form of compressed sacs are disposed upon each side of the back; but those flat round sacs, like thirty pairs of plates, opening laterally, are situate above the abdominal cavity, and concealed from view externally by a thin, loose, reticulate exterior integument. Home imagined that the intestinal cæca extended into these sacs. Again, in others of those annelides we observe more perfectly formed air-sacs, opening from the sides, and extending into the interior of the body. A transition to these is formed by the compressed lateral sacs of the *halithea*. Those which present this structure have been termed cryptobranchia. Those in which we observe the gills disposed on the back have been called dorsi-branchia. Thus three orders have been established among the annelides from the form of their respiratory organs. Numerous regular pairs of those respiratory air-vesicles are seen in the leech, separated from each other, by about five segments of the body. We observe their round form, and internal position, and highly vascular mucous lining, also in the common earth-worm, where they are seen opening, each by a separate round orifice, upon the sides of the body. Those little respiratory air-sacs, opening by small orifices upon the surface of the sides of the segments in the earth-worm and the leech, destined to convey supplies of fresh air for the aeration of the circulating red-blood, present us with a simple but an interesting rudimentary condition of that most complex respiratory apparatus, the ramified tracheæ of insects. We have here already in these annelides not only the stigmata, the pneumostomata, the spiracula, as they have been called—those apertures along the sides that lead into the tracheæ of insects, but we have even the commencement of the tracheæ themselves in those pulmonated annelides. Upon those little air-sacs which generally contain a white mucous fluid on being opened, the blood is distributed, and submitted to the action of the inhaled atmospheric air. This simple structure may be capable in some of admitting either water or air into their interior, and thus many of the aquatic annelides, which have this structure, as the common earth-worm or the leech, may respire, by means of these sacs, either in or out of the water, or they may abstract air from the water itself.

In the myriapods, the lowest of the entomoid classes, we find a condition of the respiratory organs much more complex than that of the annelides, and which is destined entirely for atmospheric air. On the sides of the segments, we observe very small but very numerous apertures placed singly, as in insects, that lead into ramified tracheæ or air-tubes. Those tracheæ in most of the *myriapoda chilognatha* subdivide immediately from each of the stigmata, and thus they differ somewhat from the insects. In the *scutigera* the stigmata open on the middle of the back. In the true insects, we observe two great lateral tubes receiving air by short canals from the stigmata, and extending along the sides of the body, from which common lateral trunks all the complex ramifications of tracheæ and air-sacs of the body are given off; but in those myriapods where they subdivide more quickly into tufts of air-vessels, we have an intermediate stage of development between that of the round simple air-vesicles in the pulmonated annelides and the long lateral trunks and ramifications we meet with in the insects.

In the class of insects we already observe two lateral series of stigmata leading to ramified tracheæ in the larva condition; but in the perfect insects, where all the organs have arrived at their complete development, we observe that those stigmata surrounded by distinct prominent edges, often ciliated and opening on the sides of the abdominal segments, lead into two long parallel lateral tracheæ, that ramify like bloodvessels through all the parts of the body. They ramify through all parts of the trunk of the animal, through the head, the interior of the eyes, the antennæ, the extremities of the body to their minutest parts. When we trace these tracheæ towards their terminations, we observe them often leading into vesicles of various sizes and forms, which have most generally, however, a lengthened and oblong form; but upon applying powerful microscopes to the surface of those terminating vesicles, we can see still more minute ramifications extending from them to reach the minutest parts. Those tracheæ which we observe in insects present a complicated structure; they consist of three tunics,—an interior soft white homogeneous mucous membrane corresponding in its thinness and want of fibres with that very dense shining white tunic which we see upon their exterior surface; but between those two coats we

observe an elastic firm tunic marked by transverse lines as if they were muscular fibres. Upon drawing out, however, this middle coat of the tracheæ by tearing asunder a portion of the trachea, we perceive that these are continuous spiral filaments, like the spiral filaments of a plant, and that those continue to wind round the whole of the tracheæ to the minutest points from the commencement of the stigmata, giving them the necessary elasticity to prevent obstruction to the passage of air. These enlarged figures of Straus and Goldfuss show the structure and mode of ramification of several parts of the tracheæ of the *melolontha*, and the other figures exhibit how extensively they are ramified through all the minutest parts of the body, the branches coming from the two principal lateral tubes into which the air is conveyed from the exterior stigmata and ramified through the viscera, the muscular parts, the wings, and all the minutest textures, so that the limited circulation of the fluids is compensated for by the extensive ramification and distribution of the respiratory apparatus, and the necessary lightness, elasticity, buoyancy, and muscular energy, are imparted to the body of these invertebrated inhabitants of the air.

In the arachnida we observe, as in the myriapoda, a more extensive circulation of the blood, and a more concentrated form of the respiratory system, which consists of organs adapted for atmospheric air. In some of the lowest arachnida we observe still a respiration by means of tracheæ or of ramified air-tubes, as in insects. In others, as in the spiders and in the scorpions, we perceive numerous distinct sacs opening from the sides of the abdomen, into which the air is freely conveyed. Those eight sacs in the scorpion open by long oblique stigmata from each side of the abdominal segments. They consist of four detached white soft sacs on each side, which you observe opening by large prominent stigmata from the abdominal surface in those four wide segments. When we open those respiratory sacs in the scorpion, we observe that their internal surface is not smooth like the air-sac of a snail with a myriad of capillary vessels spread over it, but that they possess a laminated or pectinated character internally, and that they have thus internally somewhat the characters of branchiæ. They form the pneumo-branchiæ of the French writers; presenting the internal form of an aquatic organ, but yet having the function of the air-breathing sacs. The same structure exists also in the respiratory abdominal sacs of the spider. Those sacs present us characters indicating a more concentrated and higher degree of development than where we find these organs frittered down to mere ramified vessels, as in the myriapods, the insects, and the tracheated tribes of arachnida. We observe this ramified or divided condition of organs to be generally a mark of inferior development, and the more concentrated form, though externally more simple, is more elaborated internally, and belongs to a higher grade of its formation.

In the crustaceous animals the respiration is aquatic and performed through the medium of gills; those gills are disposed sometimes on the outer surface of the body, and sometimes they are concealed beneath the sides of the dorsal shell. In the higher crustacea, in the decapods, we observe the branchiæ attached to the haunches of the legs, so that they profit by all the motions of the legs themselves in their progressive movements. We observe them also distinctly attached to the outer pairs of maxillæ. Now those outer pairs of maxillæ, three in number, are the most convertible in the crustacea into feet; indeed, all those parts are convertible; but these maxillæ, with their attached branchiæ, so far already approach to the condition of feet; and as the maxillæ of vertebrata are obviously analogous to the ribs, we see that these feet of the crustacea are obviously analogous to the ribs of serpents and other vertebrated animals. The branchial organs of the lowest entomostracous crustacea are attached generally to the sub-abdominal appendices, they hang down freely, and move incessantly to and fro with great rapidity, and they possess a very simple structure, consisting of a fringe of respiratory filaments around these appendices on which the blood is distributed, and thus exposed to the air contained in the water.

The blood is sent to those respiratory branchiæ in all forms of the crustacea by the veins, which, returning from all parts of the system, unite into large trunks to form the branchial arteries at the base of the gills. The blood is distributed over those numerous branchiæ, whether internal or external, which present in the higher crustacea a complicated series of thin laminæ divided and pectinated, and placed in close proximity to each other, and those are exposed freely to the action of the water in the tectibranchiate forms, by the streams that are forced constantly inwards from the anterior parts, by the action of two firm valvular plates kept in constant motion. These covered branchiæ are not in fact concealed in a completely closed cavity as they might at first appear, for when you lift up or force aside slightly the exterior carapace, we can easily perceive that it is not a shut cavity enclosed

by a membrane from the free transmission of the water, but that the cephalothorax simply hangs down laterally over the surface of their ciliated laminæ, and thus protects those important complicated and delicate organs.

There is apparently greater variety of form and structure in the molluscous than in the articulated classes, and this diversity is nowhere more conspicuous than in their respiratory organs. It is beautiful to observe how nature has provided many animals low in the scale, and apparently the most inert and motionless, with the means of rapidly renewing the water in immediate contact with their bodies, so as to effect respiration, and to aerate and renovate the properties of their blood. Most of the molluscous classes of animals are remarkable for the slowness of all their movements, whether they consist of creeping motions, or of motions by which they swim through the sea, and this corresponds with their limited extent of respiration. Many of those molluscous animals indeed we see permanently fixed, and growing as inert fleshy layers over the surface of rocks; others, covered externally with calcareous shells, we perceive fixing themselves by those shells to the surface of submarine bodies. Yet, when we examine them in the living state, and in their natural element, we observe that, although apparently motionless, they have the means of rapidly conveying currents of water over that delicate piece of structure on which their bloodvessels are distributed to receive the influence of the air contained in that element.

The greater number of the tunicata, the lowest of the molluscous classes, are fixed animals, which, we have seen, are closely allied in most of their internal structure to the inhabitants of bivalved shells. The external tunic with which they are covered is generally so elastic, that it is capable of dilating by its own properties, when it has been forcibly contracted by the muscular tunic that is within; and in forcible expirations we observe those animals to contract that muscular tunic, and to retract the exterior covering, so as to propel with considerable impetuosity, and to a distance, the water that fills their respiratory cavity. The elasticity of the tunic tends to overcome the resistance of the muscular coat, and to expand to a certain extent the respiratory cavity. Without, therefore, the existence of elastic ligaments, such as we find in the conchifera, there is a partial means of enlarging the respiratory cavity given to those truncated animals. But this constant and alternate contraction and expansion of the exterior tunic you do not see in any known tunicated nor in any conchiferous animal. The streams that rush in through the respiratory orifice of the sac, are smooth, regular, and incessant. The exterior tunic remains, during active respiration, uniformly distended and motionless, and yet you perceive, that through the anal orifice the streams are conveyed outwards with continuity, smoothness, and regularity. Wherever this is the case, I have always observed that those currents are produced by the rapid vibration of cilia, disposed both on the branchiæ themselves, and on the fringed edges of the branchial aperture; for all of the conchifera, and all the tunicated animals, are aquatic animals, breathing by means of gills or branchiæ. The vibratile cilia are always disposed around the interior margin of those minute meshes which compose the gills both in the tunicata and the conchifera. The water is thus brought in with a continuous stream through the respiratory orifice in those tunicated animals; it is brought into a large interior sac, separated from the abdominal viscera, and the interior parietes of that respiratory sac are covered over with numerous beautifully-disposed regular folds or laminæ upon which the bloodvessels are minutely distributed, as you see in the plates of Savigny and Cuvier. Sometimes this interior respiratory sac, in place of laminæ, has regular tufts attached to its parietes, and over the surface of those reticulate organs the venous blood collected from all parts is distributed before being sent to nourish the various organs. This water, which is continually conveyed into the sac through the branchial aperture, rushes out through the anal orifice, near to which the rectum always terminates; so that we observe the act of respiration here, as in some other classes, assists in the expulsion of all discharges which may be thrown into the interior of the respiratory sac or the mantle.

This is the common mode of respiration of those more perfect and single tunicated animals, as the ascidiæ. In some of the inferior tunicata, however, the respiratory orifices are found at the opposite extremities of the body, as in the pyrosoma. In those separate animals composing the pyrosoma, we observe the streams conveyed into one extremity of the body, and propelled through an orifice at the opposite extremity. Those respiratory orifices of the pyrosoma extending from the outer surface of the general tube, project in the form of lengthened transparent soft papillæ on the sides of which they open. The respiratory sacs all communicate by their vents or anal orifices with the interior of the general tube composing this com-

pound animal, so that the streams are sent into the interior of the tube after the function of respiration is effected. As this tube is open at the lower part and closed at the upper, the effect of all those streams is to propel the water downwards through the inferior opening of the tube, with the force of all the cilia of the two extensive lateral gills acting at the same time. The result of this forcible propulsion of the streams downwards is a constant equal resistance against the upper closed part of the tube, the tendency of the water being to escape equally at every point of the tube. The consequence of this pressure upwards against the closed end of the tube, is the motion of the whole animal upwards through the water. So that we see the respiratory organs both of the fixed and of the moving tunicated animals are essentially of the same structure and same nature. And, as in the lowest ciliated animalcules, we still find the respiratory organs subservient to progressive motion, and even to the obtaining of food.

In the inhabitants of bivalve shells, the structure of the respiratory organs is remarkably similar throughout the whole class. Most frequently we observe in the conchifera two apertures of the mantle extending from the shells; those two apertures lead into a general respiratory cavity formed by the mantle, that muscular and secreting organ upon which we have seen that the existence and form of the shells depend. Those two apertures to the respiratory cavity sometimes extend to a great distance from the shells, as we see in those conchifera that reside in the cavities of rocks. All those piercing conchiferous animals we observe residing in timbers or in rocks, or in softer materials as mud or sand, are provided with a continuation of the mantle, which forms a tubular prolongation of the respiratory cavity. The streams of water are seen incessantly rushing, in the natural condition of the animals, through the respiratory orifice by the rapid vibration of cilia, disposed as in the tunicata both on the mantle and on the gills. The streams of water thus brought into the interior of the respiratory sac, come in contact with the two lateral pairs of pectinated branchiæ; after passing over those respiratory organs, the streams are propelled outwards in a continuous smooth current through that orifice near to which the rectum terminates.

These respiratory organs of the conchifera are remarkable for their regularity and similarity of form throughout the different orders. In this respect they have assumed a much more definite form and greater symmetry than we find in the first molluscous class, the tunicata. From the branchiæ being here in the form of two pairs of pectinated laminæ, these animals have been named lamelli-branchia, taking this name and character from an important part of their internal organization, rather than from the form of the calcareous exudation which covers their surface. It is a character by which they are remarkably distinguished from the tunicata, where the branchiæ are never found in this form of two pairs of pectinated laminæ.

Those pectinated laminæ generally hang down two on each side in the interior of the respiratory sac from the ventral or anterior surface of the abdominal viscera, connected at their upper edges or dorsal margin with the interior surface of the mantle. They present a striated appearance, the striæ extending transversely from their dorsal towards their free ventral margins. The mantle hangs over the exterior surface of those branchiæ, so as to be the part that covers the respiratory and all the other organs, and is next the interior surface of the shell. The currents of water for respiration are seen as regularly and smoothly and continuously rushing into the respiratory sac during the living and active state of the conchifera, as we see in all the tunicated animals; and these currents in all the acephalous mollusca are produced by the same action of vibratory cilia, as indeed in almost every other known form of aquatic respiratory organs. The margins of the mantle, and especially around the respiratory orifice, are also ciliated. The cilia are disposed chiefly upon the respiratory laminæ themselves; and when you take a small portion of the gills of the common fresh-water muscle for instance, which you find living in the bottom of the large pools of water in the vicinity of London, and put that portion of the living branchia in water under an ordinary microscope, you will observe, that this pectinated lamina consists almost entirely of parallel filaments, placed at a little distance from each other; and that they are traversed by smaller filaments at right angles to them, so as to divide the whole portion of the gill into a series of rectangular meshes or square figures. When you direct the glass downwards upon the interior surface of those quadrangular spaces formed by the crossing fibres, you perceive something along the edges of all the meshes like streams of blood, like moving globules forced round the interior of those passages in rapid, incessant, and most regular currents. Upon watching, however, with more attention you will soon perceive, that that appearance of a continuous circulation round all

the meshes of the gill is not the motion of globules of blood, but of minute vibratile cilia; that that goes on incessantly in the same order as in the respiratory organs of all water-breathing animals, and that there is no reverse motion perceptible in the direction of those moving cilia. So that we observe, upon examining microscopically, in the living state, the intimate structure of any of the respiratory branchiæ of invertebrate or vertebrated animals, a perfect explanation of those smooth, continuous, and incessant streams which we see rushing over the surface of all those laminated, pectinated, reticulate, or ramified respiratory organs, external or internal, which we see in aquatic animals.

In the gasteropodatous class of molluscous animals, the forms, and even the nature, of the respiratory organs are varied to a much greater degree than in the acephalous classes. The greater number of the animals of this class belong to the order called *pectinibranchia*, from the pectinated form of their gills, as seen on the left side of the body in most of the inhabitants of mivalve, spiral, or turbinated shells. Many of the smaller gasteropodatous animals float freely through the sea; such, consequently, are almost destitute of those massive coverings that we find upon the surface for protection in the testaceous gasteropods destined for the most part to creep over the surface of rocks, and which are thus much exposed to danger from the pressure of moving masses at the bottom of the sea. These light floating species, therefore, are generally destitute of any trace of a calcareous skeleton, as you see in this beautiful *scyllæa* which is found adhering to and eating the fuci that are floating in such abundance in the warmest parts of the ocean. We see the *tritonia*, the *eolis*, the *glaucus*, and many similar gasteropods, entirely naked, and the branchiæ exposed on the outer surface of the body. Others again of this class, as this *doris*, having the exterior surface of the body naked, but creeping exposed like testaceous gasteropods at the bottom, have a large disk or muscular foot covering the surface of the abdomen by which they have a very secure hold of the rocks upon which they creep. Such of these gasteropods as have this naked exterior of the body, have, like the naked annelides, a greater latitude of surface for the distribution of their external respiratory organs, and their whole surface is in fact respiratory. The *scyllæa pelagica* before you has the branchiæ exposed freely upon extended fleshy folds of the mantle arranged along each side of the back; each of those folds of the mantle has a series of beautiful small respiratory tufts through which the blood is alternately propelled and withdrawn. In the *tritonia* we find nearly a similar structure. There are two ranges of those respiratory tufts along the back of this *tritonia arborescens*, indeed it is from that arborescent appearance that this animal has derived that name. In the *doris* we see those respiratory branchiæ placed at the posterior part of the upper surface of the animal around an aperture formed by a circular fold of the mantle. Where the respiratory organs are thus freely exposed to the influence of the water, there needs no complicated apparatus of ciliated tubes or canals to bring fresh currents of the water incessantly into contact with them; the animals are floating constantly in the element, and that element is in incessant motion over all parts of the ramified gills by the cilia which cover their surface. It is chiefly from the form and the position of the respiratory organs of gasteropods that zoologists have subdivided them into orders, and those orders have received names which indicate the positions of the respiratory branchiæ. Sometimes the branchiæ are collected into one part in the middle of the back, and those have been called nucleo-branchia, such as we see in the carinaria. In others again, as in most of these naked gasteropods, where the branchiæ are more or less extended over the outer surface, they have received the name of nudi-branchia. Sometimes we find there is a dorsal calcareous lamina contained in the middle of the back, and below this, protected by a fold of the mantle, the branchiæ are disposed; such have been called tecti-branchia. Others, again, without shell and with gills protected by a lateral fold, have received the name of infero-branchia; others with the gills under a scutiform open shell, have been called scuti-branchia; others with circular gills under the margin of the mantle, are the cyclo-branchia.

In the pectinibranchiate gasteropods the water taken in for respiration is conveyed backwards by the incessant vibration of cilia over the branchiæ, and is then interrupted by the closed part of the mantle behind, and is directed from the back part of the respiratory sac to the right side of the body. It escapes, therefore, over the surface of those passages that open upon this right side as the anus, and the commencement of the male organ in that sex, the anus and the opening of the oviduct in the female, and over the muciparous glands. In some few of these gasteropods, where the shell has its spire directed to the left instead of the right side of the body, the heart and the respiratory organs are always found upon the

right instead of the left side of the body, thus having the position reversed; which in fact we should naturally expect, if those parts had anything to do with the spiral turn and the general form of the shell. You are familiar with many pulmonated gasteropods, from their occurring on the dry land of all continents, both those forms which are provided with shells and those which exist without shells; and many of these air-breathing gasteropods occur in the fresh waters in every part of the globe. These species breathe by means of pulmonary cavities opening on the right side, and not by gills. You see that in those little testaceous gasteropods the *lymnea*, the *planorbis*, and many others that swarm in all the pools of fresh water. Those little testaceous gasteropods, although inhabiting the water, respire by an opening on the right side of the anterior part of the body. Among those we observe, for instance in the snails, that there is an opening on the right side of the body which leads to a capacious highly vascular sac, destined to receive atmospheric air. When we open this single and simple respiratory cavity, and examine its internal parietes, we perceive that it is provided with a complicated plexus of minute bloodvessels closely extending over the whole of its interior surface. It is a comparatively small respiratory organ, but it is to be considered that the air is taken into this cavity in a pure and unmixed state, unmixed with water, by which so many of the gasteropods receive their atmospheric air. They have in fact a more perfect or extensive respiration than any of the other gasteropods; and we observe that their general organization partakes of its powerful influence. Some place at the head of the class of gasteropods in their classical arrangement those pulmonated genera, from their superior respiration and their superior development.

It is interesting, in tracing the development of these air-breathing organs, to observe the air-sacs by which the lowest classes of animals breathe, throughout all their modifications of outward form and general organization. We see air-sacs in the physograde acalepha. We see them in the leech and in the earth-worm, and of a simple structure in those animals; we see them subdivided, complex, and ramifying to infinity in insects. They become more plain externally, and more elaborated internally, in the abdominal sacs of the pulmonated arachnida, as in the scorpions and the spiders; and we see them here in the pulmonated gasteropods, consisting of a single sac, placed nearly in the middle of the back, the position in which we find the air-bag of fishes. Now you will perceive that they nowhere as yet communicate with the mouth, and that we have not yet seen any animal, in rising thus from the monads, that breathes water or atmospheric air through the mouth; that is an organ in these lower classes which is appropriated to the reception and subdivision of the food.

In the pteropodous animals we observe beings that have many characters in common, and many living habits corresponding much with those floating naked gasteropods to which I have already alluded. Like these they have often a naked exterior, fleshy and vascular surface, or they are provided only with a light exterior sheath, soft and cartilaginous, or of a thin, pellucid, horny texture, or slightly consolidated by calcareous matter, but never presenting a solid, massive, and heavy calcareous shell. Those testaceous pteropoda have the shell covered externally with a thin layer of the mantle, which, like the surface of the naked gasteropods and the naked pteropods, may serve as an assistant respiratory organ to the true branchiæ, which all pteropods possess. From the mantle being closed, and forming a short abdominal cavity in this class, and from the pteropodatous animals, swimming to and fro in the sea, by means of fin-like expansions, they have the gills for the most part disposed on some external portion of the body. The parts of the body which are most subjected to the contact of fresh strata of water, are those fin-like organs by the motions of which they are carried through the sea. Generally we can perceive innumerable minute ramifications of the branchial arteries and branchial veins distributed over the surface of those swimming expanded folds, or on distinct pectinated folds on their surface as here in the *clio*, presenting the pectinated appearance of ordinary branchiæ. The position, however, of the respiratory organs is not constant in the pteropods. Sometimes they are placed more towards the posterior extremity of the body, as in the *pneumo-dermon*, where they form two crescentic gills on the caudal extremity of the body. In the *hyalea* and the *cleodora* they are developed from the sides of the mantle. The fin-like lateral expansions of the *cimbulia*, like those of the *clio*, support the branchial laminæ, by which all the actions of swimming contribute to aerate the venous blood sent over these exposed branchiæ.

In the cephalopodous inhabitants of the polythalamous shells we might expect to observe the nearest approach in the form of the respiratory organs to those which we find in the pectinibranchiate gasteropods. The mantle is not here

closed above as it is in the pteropods, but allows the free ingress of water to branchiæ placed in the interior of the abdominal cavity in all the animals of this highest of the invertebrated classes. All the cephalopods are aquatic, and all have the branchiæ symmetrical on the two sides of the body. In the *nautilus pompilius*, which is one of these testaceous cephalopods, we find two branchiæ on each side, and a considerable difference in the development of those two respiratory organs, although they are symmetrical on the two sides of the body. We observe here one large pectinated gill and a much smaller one on each side of the interior of the mantle. This is a structure upon both sides of the body very similar to what we commonly find in the pectinibranchiate gasteropods such as the common *buccinum*, developed only upon the left side of the respiratory cavity. There is an obvious reason for their being developed only on the left side of the body in those pectinated gasteropods, because their excrementitious orifices terminate on the right side of the cavity, and the streams carried in by the left side to aerate the branchiæ come over the surface of these outlets in passing out from the interior of the respiratory cavity of the mantle; but in all the cephalopods the two sides are symmetrical, the terminations of the alimentary canal and the passage for the products of the oviducts and the male organ are placed on the median plane, so that there is no reason why these respiratory organs should be developed only upon the left or only upon the right side. The development here has therefore proceeded equally upon both sides of the body, and in this symmetrical development of the respiratory organs on the two sides of the body we see an approach in these organs of the cephalopods to their regular and symmetrical forms in the higher classes of vertebrata. But taking one side of the *nautilus* we still perceive in the branchiæ the form which is so common in the class of gasteropods. They consist, in the naked cephalopods, of numerous curved pectinated subdivided folds which are attached loosely by ligamentous bands to the sides of the interior of the cavity of the mantle, so that they float loosely in the water that is brought in from their sides over their surface. The venous blood returning from the whole system in the naked cephalopods is conveyed through two branchial arteries, one upon each side, next to the ligamentous band, to those respiratory organs; from the respiratory organs the arterialized blood is conveyed by the branchial veins along the free floating margin of the gills to the great fleshy systemic ventricle which sends it by arterial trunks backwards and forwards through the system. The relative size of the respiratory organs varies a little in the different kinds of cephalopods, according to the general form of the body and its adaptation for active or vigorous motions. The entrance of the respiratory streams by the two sides of the mantle, and its exit by the funnel placed on the median plane, presents us already with three passages for respiration as in fishes, although the currents here take an opposite direction.

Thus we observe in the invertebrated classes that the entire surface of the skin is subservient to respiration in the lowest tribes before a particular portion of it has become appropriated to this function. That portion allotted to the aeration of the blood forms the gills or the pulmonic cavities, which are situated in the most convenient position for receiving that fluid and exposing it to the influence of the surrounding element. As we see the air to traverse extensively the interior of the body in many of the terrestrial species, we find the water to have a like free admission and extensive distribution through the body by appropriate canals in most of the aquatic invertebrata.

LECTURE LI.

ON THE RESPIRATORY ORGANS OF THE VERTEBRATA.

It is chiefly by the form of the respiratory organs that the fish is adapted for the water and the bird for the regions of the air. Indeed there are scarcely any organs of the body which present greater diversities of form in the vertebrated classes, or which undergo more marked changes during development, than those which are appropriated to the aeration of the blood, and those diversities of form are most intimately connected with the living conditions of the animals and the vital energies they are capable of displaying. The extent and importance of this system increase as we ascend in the scale, and the necessity of its function to the continuance of life keeps pace with the extent of its development, and with the general complexness of organization. In the slow-moving reptile, as in the molluscous animal, where the respiration is small, it may without inconvenience be suspended for a time, but in the active inhabitants of the air, the birds and the insects, where this function is necessarily of great extent, its suspension proves quickly fatal to life. From the small proportion of air contained in water,

the aquatic respiration is less favourable to the aeration of the blood than the aerial, and almost all the active tribes of invertebrata are air-breathing animals, while the slow-moving classes are inhabitants of the sea. In the vertebrated classes, we still find animals possessing only this simple means of respiration; but in order to render it as effective as possible, the whole of the blood is sent through these aquatic organs, and with a velocity aided by the entire force of the heart. Their blood is thus oxygenated, and decarbonized, and replenished with nitrogen for the gaseous secretion of their air-bag. Their naked surface is ciliated, vascular, and respiratory, like their gills, and like the external branchiæ of the amphibia, and some are seen to swallow draughts of atmospheric air, to aerate the vascular mucous surface of their intestine, or to convey through the ductus pneumaticus to the air-bag. The fishes being deprived of the communicating anastomosing branches between the branchial arteries and veins, retain permanently the earliest tadpole state, incapable of complete metamorphosis, and all the species of this great class agree in this permanent aquatic character.

In the animals of this class we observe the respiratory organs to consist of variously formed gills, attached to those osseous or cartilaginous branchial arches seen extending from the sides of the os hyoides upwards to the sides of the cranium. In the osseous fishes we observe that there are four of those water-breathing organs, disposed in a free and moveable condition, under a wide operculum upon each side of the neck; these branchiæ consist of closely approximated series of minute, flat, cartilaginous, tapering, and bifurcated laminæ, like the teeth of a comb, over the surface of which the blood is minutely distributed in capillary vessels. The venous blood which has been collected from all parts of the body is propelled by the heart through the great bulbus arteriosus and branchial artery, which divides into a number of arterial branches, corresponding with the number of branchiæ on the two sides. They reach the grooves along the outer convex margin of the branchial arches, and we observe that they are there placed exterior to the branchial veins. The branchial veins conveying the arterialized blood from all the close, parallel, thin laminæ, are lodged in a secure cavity along each of the arches; the minute branchial arteries are observed in each leaflet of the gills to run in the middle part of these bifurcated laminæ,—an arterial twig for each of the laminæ. These subdivide over the whole surface of each of those thin plates, and are continuous with the capillaries of the branchial veins, which occupy the margins of the small laminæ. All the branchial veins from these laminæ, collected together, enter the great single branchial vein of each gill which runs along the bottom of the groove in the outer margin of each branchial arch. Those branchial veins, returning the arterialized blood, are all collected at the upper and back part of the body into a single great systemic artery, after giving off some branches to the head, and from this arterial trunk, without the aid of a heart, the blood is propelled through the system. You will observe that we are now speaking of vertebrated animals where all the systems of organization are greatly advanced, and have to push rapidly forwards to this high degree of complexness, and where, consequently, the respiration, one of the most important functions, requires to be conducted, though by means of an aquatic element, with great velocity and effect. For this purpose it is not sufficient that the fishes should have merely ciliated tufts hanging loosely at the sides of the neck, but that they should have the means of rapidly and constantly propelling large fresh streams of water over their surface, and of forcing by the action of the heart the whole blood of their system forwards through the respiratory system to be subjected to the influence of the air that is contained so scantily in the water. Therefore it is that the heart is placed in them in such a position as to affect the respiratory system, and not the system at large. But this branchial heart in fishes is the one from which the systemic heart is developed in higher air-breathing vertebrata.

The great development of the muscular system in fishes for the motion of their vertebral column, acts upon their systemic arteries and systemic veins, assisted by the valvular structure, with sufficient energy to conduct the circulation without another heart being placed upon their course. This is the condition of the circulation of man himself, and of all the higher vertebrated animals at the commencement of their fœtal condition, when they have arrived at that stage of development at which the fishes have been arrested.

We find those branchial respiratory organs in fishes to vary in different species in their number and in their forms. The most frequent form is that which we see in the osseous fishes, with four parallel series of pectinated laminæ on each side of the neck. In the rays and sharks, we see, on each side of the neck, five of those branchial openings, and the

gills do not float freely at their distal extremity, as they do under a single opercular covering in the osseous fishes, but are connected at their distal extremity with the integuments, so that the water taken in passes over all their surfaces, and is divided into a corresponding series of streams. Thus it is that we observe those five oblique apertures, without any distinct operculum, in the sides of the neck in the rays and sharks. In the *lampreys*, the structure is somewhat similar to that of the sharks with regard to the fixed condition, at the distal extremity, of their respiratory laminæ; but here there are seven of those respiratory internal separate sacs, with external apertures of a round form upon each side, through which the water enters, and passes out, as in the lateral respiratory sacs of worms. In the long cylindrical *gastro-branchus*, the number of branchial round openings is only two, which are the terminations of two common lengthened canals that receive the whole of the branchial currents, and convey them to the surface. In some fishes, in place of those pectinated organs which you see so common in the osseous and in the cartilaginous fishes, the gills have the form of branched tufts disposed along the branchial arches, and these tufts have some resemblance to the condition of those organs in many gasteropods and annelides. Such fishes have been denominated from this structure lopho-branchii —fishes that breathe by gills in the form of tufts, as you see in the *pipe-fish* and the *pegasus* and the *hippocampus*.

We observe, in the greater number of the animals of this class, that there is an air-bag disposed along the middle of the back which contains a gaseous secretion, that gaseous secretion differing from atmospheric air in its constitution. In the fishes which inhabit the deep seas, generally more muscular and powerful than the shore fishes, or the inhabitants of fresh waters, we find that there is a preponderance of oxygen in the constitution of that gas which is contained in their air-bag, and that the abundance of nitrogen generally increases as we come to the feebler fishes which inhabit the shores of the sea, or the shallow lakes and rivers. This air-bag most frequently communicates with some part of the cavity of the alimentary canal near to the stomach, by means of a short wide canal called the ductus pneumaticus. Often this air-bag forms a simple shut sac with an obviously glandular, internal, red-coloured, highly-vascular organ, which secretes the gaseous fluid, and without having a perforation in any part of the parietes of that sac for the escape of the gas; this is the case for instance with the sword-fish. In some this air-bag is subdivided, and we observe that several fishes have it subdivided in a very symmetrical manner. Some fishes have the body of this air-bag with long tubular extensions shooting out from it upon each side; in others there appears a partial longitudinal division of the middle part or body of this air-bag; in some others there is a smaller tube that communicates on each side with two lateral tufts of prolongations from the air-bag; but in others the whole extent of the air-bag shoots out laterally in the form of innumerable ramifications, consisting of so many pulmonic cells or subdivisions symmetrically disposed upon the two sides of the air-bag. In the sturgeon, that air-bag communicates by a wide orifice with the cardiac extremity of the stomach. In the diodon, there is a large sac communicating with the anterior part of the œsophagus, which the animal has the means of filling directly with atmospheric air by coming to the surface, and swallowing great draughts of the atmosphere from the surface of the sea; by this it distends not the stomach, but a large air-bag that communicates with the œsophagus. In this way the whole body is blown up, and rendered spherical and tense on the surface; the spines covering its surface are thus erected, and the fish rises buoyant, and floats with the greater part of its more delicate abdominal region altogether above the surface of the sea, so that the fishes that are pursuing it are unable to seize it, from the long dorsal spines which protect it, while it is shielded also from the birds above by the spines covering the abdomen.

In many fishes which reside in mud, or lie at the bottom of the sea, the air-bag would be worse than useless, and is wanting, as we see in lampreys, and rays, and frog-fishes, and flounders. So that we see this air-sac, so useful in the living movements of fishes, and but little subservient to their respiration, to present the embryo conditions of the complex respiratory organs of the highest vertebrata. In many fishes, as in the embryo of mammalia, it is a simple and single shut sac, placed on the median plane. In others it manifests internal divisions or cellular prolongations, as in reptiles, or a bifurcation of its cavity. The ductus pneumaticus receives air, often pure, and often derived from the respired water, as that sent into the tracheæ from the branchial openings of some aquatic insects in the larva state. The ductus pneumaticus, still membranous, like that of a proteus, is sometimes single and sometimes double, and its opening is sometimes as low as the stomach; in others

it opens into the œsophagus, and in others as high as the pharynx.

The number of branchial pairs varies in fishes, as we see also in the amphibia; in the *diodon*, and several other plectognathi, there are only three pairs of gills; in the *lophius* there are three pairs, and the rudiment of a fourth anterior pair; the most frequent number is four pairs complete, but many have, besides these, four full-sized branchiæ, the rudiments of an anterior fifth pair, and we have seen that the number is greater in many of the cartilaginous fishes. Besides the internal ordinary covered branchiæ of the rays and sharks, we find in the fœtus of these fishes, numerous long, external, simple, branchial filaments hanging down from the sides of the openings of the gills, which are lost before the fœtus escapes from the ovum. These external tufts of respiratory filaments have also been observed in several other fishes at a very early period of their fœtal life. Now at an early period of the development of fishes, the outer surface of the neck appears to have no branchial openings, but there are soon formed five small separate holes on each side; even in the operculated osseous fishes, the branchial arches are formed, and the minute branchial respiratory laminæ begin to bud out from their edges. These laminæ increase in number and extent and firmness, and hang free from the sides of the head till the development of the opercular apparatus covers and conceals them by the extension of its branchiostegous membrane and rays. We see thus in the respiratory organs of fishes, a perfect adaptation to the aquatic medium they are destined permanently to inhabit. They present many analogies with the forms of these organs in the invertebrated aquatic tribes, and the closest resemblance to the tadpole condition of the class above them in the scale. In the branchial subdivisions of their great arterial trunk, issuing from a single heart, we observe the embryo conditions of this vessel in all the higher vertebrata; and in the various forms of their air-bag, with its ductus pneumaticus, we see repeated the first efforts at development of the lungs of all the higher air-breathing classes.

The amphibious animals breathe at first by means of gills, like the fishes of the sea; their air-bag is double, and is now more obviously subservient to respiration, and they respire by the whole surface of their naked skin. In watching the development of the tadpole from the time of its escape from the ovum, where it appears as a small black spot, coiled up in the centre of the transparent colourless gelatinous globule, we observe from the sides of its neck, simple branchial filaments extending, which, when we view it with a microscope or lens in water, are perceived to have currents of water rapidly and incessantly passing over their surface. If we watch them with attention during their rapid development, we observe that those extended branchial filaments develop from their sides small supplementary ramifications; that each of those branchial extensions is formed by the subdivision of a bloodvessel; that each of those terminal extended portions of the exposed gills has only a single capillary vessel extending round its margin; that that branchial capillary vessel by simply giving off a loop from its sides forms a new extension, an additional circular vessel, and a new part is in this manner successively added to those external projecting branchiæ. Those are the kinds of external aquatic respiratory organs which are first developed in the tadpole state of these amphibious animals. The whole of the venous blood of the system collected into the right auricle of those tadpoles of the highest amphibious animals is sent to the single ventricle, and from this ventricle it is conveyed, as in fishes, through a bulbus arteriosus and branchial artery which entirely ramifies on those external branchiæ.

The branchiæ, as we saw in the fishes, are not the same in number in all the amphibious animals, and many commence with external filiform branchiæ, which are changed for internal branchiæ at a latter period. We observe that in the larvæ of the common frogs and toads, and in most of those amphibia which are destined afterwards to lose their branchiæ, there are four of those external gills on each side, supported by branchial arches attached to the os hyoides; while others, as the *syren* and the *proteus*, have only three of those branchial tufts on each side, as you observe also in the *axolotl* of Mexico. Those gills are supported in the same manner as the gills of fishes, upon branchial arches connected with the cornua of the os hyoides. It is by the motion of the lower jaw and the os hyoides, drawing in water by the mouth, that the aeration of those branchiæ is partly effected, whether they be external or internal. But as the whole surface of the branchiæ is minutely covered with cilia, or vibratile organs for rapidly renewing the stratum of water in contact with their surface, we see that, independently of the action of the jaws and os hyoides, those free projecting branchiæ have, as in the branchiæ of inferior classes, the means of

rapidly aerating the blood distributed upon them. The whole of the blood of the system is sent through, and collected from, those branchiæ, and is sent partly to the head by small branches, and by two great trunks into a single abdominal aorta, which sends it through the rest of the system, as in the class of fishes. So far as the subdivision of the aorta into pairs of branchial arteries is concerned, this is the first condition, not only of fishes and amphibia, but of all the vertebrated classes. The whole of the systemic blood in animals, from man down to fishes, appears at first to be sent in precisely the same manner from the single undivided heart, consisting of a single auricle and a single ventricle, through these branchial subdivisions of the aorta. But the shortness of the period during which the higher vertebrated animals remain in their primitive aquatic element, is not sufficient to produce the complete development of those true branchial laminated organs adapted for aquatic respiration. Those branchiæ themselves have not been witnessed in the reptiles, the birds, or the mammalia, although those subdivisions of the aorta termed the branchial arteries are now familiar to anatomists in all these higher vertebrated classes up to man.

We observe in the lowest of the amphibious animals, even in those that never lose their fishlike aquatic respiratory organs, such as the proteus and the axolotl, that in the cavity of the abdomen, and extending pretty far back into that cavity, there are respiratory membranous sacs, the rudiments of lungs, as in fishes, which receive bloodvessels coming off from the trunk of the aorta. Those still thin simple membranous respiratory sacs receive their arteries from the great systemic vessel, and the blood after ramifying upon their parietes is conveyed back by veins and sent into a separate small sinus or auricle on the left side of the single ventricle, forming thus a third cavity of the heart. When we observe in these perennibranchiate amphibia the tracheal openings of those membranous sacs upon each side, we perceive that they communicate with the pharynx by a thin transparent soft membranous tube. This is a structure which we might have some difficulty in recognising as a very simple condition of the trachea, but from the appearance and general relations presented by the air-sacs of fishes, and their communication by the ductus pneumaticus with the commencement of the alimentary canal, we see that there is a structure of the pulmonary organs common in such low aquatic animals as those permanent tadpoles and fishes which constantly retain this larva state; they never leave the deep, therefore they never metamorphose. But you can already see in many of the cartilaginous fishes, as in the developing tadpoles of amphibia, that there is a tendency to the closing up of the great open opercular passage seen in the osseous fishes. Watching the structure of those respiratory air-sacs in the different genera of amphibious animals, we perceive that in the lowest forms, as in the common triton and in the proteus, they still remain simple internally, and without cells or partitions in their interior; that they are continued in the triton further forwards, of this membranous form, and terminate at the back part of the tongue, communicating thus more directly with the mouth. Thus we perceive a gradual ascent in the openings of those air-sacs or pulmonary organs, from their being completely closed sacs in many fishes, as in the earliest condition of air-breathing embryos, to their openings into the stomach, into the œsophagus, into the pharynx, and into the fore part of the mouth.

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There are no true ribs in amphibia, and the pulmonic organs are filled by a kind of deglutition effected chiefly by the motions of the os hyoides. They are unable to fill the lungs with air when their mouth is kept open, as inspiration in them is effected by the motion of the mouth and not of the trunk. Their aerial respiration has therefore some analogy to their aquatic in the actions which produce it, excepting in those of the vibratile cilia which belong

to water-breathing organs. The external filamentous simple branchiæ resembling the deciduous respiratory filaments seen in tufts in the rays and sharks, early make their appearance, and early are exchanged for the internal branchiæ in the frogs and other anurous amphibia. Thus we observe that most of the amphibia, with those three successive forms of the respiratory organs, commence with the naked respiratory tufts of many of the articulated and molluscous animals, then acquire the covered branchiæ of fishes, which are ultimately changed for the more effective cellular lungs of terrestrial animals. The aquatic and aerial organs are developed to very different degrees in these animals, and even in the perennibranchiate species, and according to their relative development is the one form of repiration or the other more important and essential to the continuance of life. In the *siren* the pulmonic respiration is more extensive and important than the branchial, but in the *proteus* the proportions of these systems are the reverse, and in the former of these [illegible]nals the lungs are cellular throughout [illegible]e land salamanders and frogs, while [illegible]*teus* they are simple undivided [illegible]he common fresh-water tritons.

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In these serpents we observe that the right lung forms generally a large, long, cylindrical, and almost entirely undivided sac, without any cells traversing its interior, excepting at the upper and back part, and that it communicates by a long bird-like firm trachea with the back part of the tongue, where the larynx is very simple and without epiglottis. On the left side we observe the lung when present to be generally in a very rudimentary state, and this almost single condition of the respiratory undivided bag in the serpents has been compared by MECKEL to the single air-bag which we commonly see in fishes and in snails, and many other pulmonated gasteropods. Generally you will observe that the upper and back part of these air sacs in the ophidian reptiles, presents in its interior a minute subdivided cellular structure formed by the extension of folds from the back part of the parietes forwards into the interior of the general cavity; so that when we open this part of the lung, it presents somewhat of the cancellated appearance of the interior surface of the second stomach of a ruminating animal; numerous delicate membranous plicæ extending into the interior of the lung, and covering the whole of that upper and dorsal surface; but throughout the rest of the lung we observe no distinct cells any where developed. In several of the ophidian reptiles, as in this *boa constrictor*, the interior cavity of the lungs has acquired a very considerable development; and this is very important in animals which like these require often to use great muscular exertions, and which often require to lighten the body to enable them to swim over lakes or rivers in pursuit of their prey. All the reptiles are observed to take in more air into their capacious and slightly subdivided lungs than is employed in oxygenating the blood, and this is especially remarkable in the aquatic kinds, where this air serves to buoy up their heavy and slow-moving bodies in that dense element.

The serpents being provided with numerous highly-moveable ribs, and powerful intercostal muscles, are capable of rapid and extensive inspiration and expiration, which contributes to the energy of all their muscular exertions. From the extent and dilatability of their lungs, and the freedom of their ribs, they can distend their body with air, and make it firm and elastic. Thus we see that it is in many ways advantageous in those animals to be able to take a large quantity of air into the interior of the body, which cannot be subservient to respiration, as it cannot all come in contact with the surface of their simple undivided respiratory sacs, over which alone the pulmonary arteries are distributed. We see the effect of this, indeed, in all the elastic bounding motions of those serpents even on the dry land. The long-continued hissing sound which they produce to alarm their prey is effected by the expulsion of this great volume of air, and which is caused by their moveable free ribs compressing these air-bags, and acting with force for a long time in expelling it through the narrow passages of the nostrils. There is an appearance of transverse bronchial markings extending per-

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From this simple undivided condition of the air-sacs, however, we find them in the amphibious animals becoming gradually more complex in their structure, more subdivided internally in the frogs and land salamanders, by numerous septa traversing in all directions their interior, which thus present a greater surface for the distribution of the blood sent off from the great systemic arterial trunk coming off from the bulbus arteriosus and the single ventricle. Those pulmonary branches which we see in the amphibia coming off from the commencement of the aorta, and which receive the same mixed venous and arterial blood from the single ventricle which is sent through all parts of the system; those pulmonary vessels have a bulbous enlargement at their origin in the class of reptiles. The pulmonic sinus or left auricle becomes larger and larger in the amphibia as the pulmonary respiratory organs increase in their extent and development. The rings of the trachea are scarcely yet perceptible on the thin membranous tubes which lead to the air-sacs of the proteus and the syren, as in the ductus pneumatici of fishes.

There are no true ribs in amphibia, and the pulmonic organs are filled by a kind of deglutition effected chiefly by the motions of the os hyoides. They are unable to fill the lungs with air when their mouth is kept open, as inspiration in them is effected by the motion of the mouth and not of the trunk. Their aerial respiration has therefore some analogy to their aquatic in the actions which produce it, excepting in those of the vibratile cilia which belong

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In the serpents, the lowest order of the true scaly air-breathing reptiles, we observe considerable diversities in the form and extent of the pulmonic respiratory organs. In almost all of them there are two undivided sacs, and there is an inequality generally in the development of the right and left lungs. Several snakes have only one lung developed, without a trace of a second cavity. This has been observed especially in many species of *coluber* and *typhlops* and *vipera*. In some species of *boa* and *python* the two lungs are nearly equally developed, but in most serpents the right lung is much more developed than the left. These respiratory organs partake of the lengthened form which we have seen in most of their viscera, and which corresponds with the long cylindrical form of the body.

In these serpents we observe that the right lung forms generally a large, long, cylindrical, and almost entirely undivided sac, without any cells traversing its interior, excepting at the upper and back part, and that it communicates by a long bird-like firm trachea with the back part of the tongue, where the larynx is very simple and without epiglottis. On the left side we observe the lung when present to be generally in a very rudimentary state, and this almost single condition of the respiratory undivided bag in the serpents has been compared by MECKEL to the single air-bag which we commonly see in fishes and in snails, and many other pulmonated gasteropods. Generally you will observe that the upper and back part of these air sacs in the ophidian reptiles, presents in its interior a minute subdivided cellular structure formed by the extension of folds from the back part of the parietes forwards into the interior of the general cavity; so that when we open this part of the lung, it presents somewhat of the cancellated appearance of the interior surface of the second stomach of a ruminating animal; numerous delicate membranous plicæ extending into the interior of the lung, and covering the whole of that upper and dorsal surface; but throughout the rest of the lung we observe no distinct cells any where developed. In several of the ophidian reptiles, as in this *boa constrictor*, the interior cavity of the lungs has acquired a very considerable development; and this is very important in animals which like these require often to use great muscular exertions, and which often require to lighten the body to enable them to swim over lakes or rivers in pursuit of their prey. All the reptiles are observed to take in more air into their capacious and slightly subdivided lungs than is employed in oxygenating the blood, and this is especially remarkable in the aquatic kinds, where this air serves to buoy up their heavy and slow-moving bodies in that dense element.

The serpents being provided with numerous highly-moveable ribs, and powerful intercostal muscles, are capable of rapid and extensive inspiration and expiration, which contributes to the energy of all their muscular exertions. From the extent and dilatability of their lungs, and the freedom of their ribs, they can distend their body with air, and make it firm and elastic. Thus we see that it is in many ways advantageous in those animals to be able to take a large quantity of air into the interior of the body, which cannot be subservient to respiration, as it cannot all come in contact with the surface of their simple undivided respiratory sacs, over which alone the pulmonary arteries are distributed. We see the effect of this, indeed, in all the elastic bounding motions of those serpents even on the dry land. The long-continued hissing sound which they produce to alarm their prey is effected by the expulsion of this great volume of air, and which is caused by their moveable free ribs compressing these air-bags, and acting with force for a long time in expelling it through the narrow passages of the nostrils. There is an appearance of transverse bronchial markings extending per-

ceptibly over the surface of the lungs themselves in some of the serpents. On looking obliquely on the surface of these dried lungs, both of the *boa* and of the *python*, you will readily perceive this transverse banded marking extending over them to their posterior closed extremity. These bronchial markings extending over the lungs of these serpents, analogous to the bronchial rings which we see continued from the trachea over the bronchi in the lungs of higher animals, were accurately described by RETZIUS, but MECKEL says that he never could perceive a trace of it in these same serpents' lungs now before you. Now, in the embryo of the *python*, MECKEL has observed three branchial openings on each side of the neck, and MULLER perceived distinct gills within a round opening, a line wide, on each side of the neck in the young cæcilia. Similar observations were made by RATHKE on the branchial openings of serpents in their embryo state, and BAER observed that in the embryo state of these common ringed snakes, the *coluber natrix*, the aorta divides at its exit from the heart into four pairs of branchial arteries, but distinct gills have not been seen developed in any of these serpents, excepting in the cæcilia, which induced MULLER at first to regard that animal as belonging to the batrachia or amphibia.

In the saurian reptiles we still find some with lungs like those of serpents, almost entirely undivided in their interior, but they are equally developed on the two sides of the body. The commencement of the subdivision into cells is seen here always to take place, and to arrive at its greatest degree at the upper and back part of the lungs. In this common officinal *scink* (*scincus officinalis*), you observe that the lungs consist of large sacs which have their parietes all marked by small internal projecting folds, but that the interior structure of these lungs forms a continuous cavity in each, and is not throughout divided into distinct cells. In the chameleon we observe that the lungs extend as in other reptiles, and like almost all the inferior vertebrated animals that respire atmospheric air (beneath the mammalia) freely into the cavity of the abdomen, there being yet no distinct diaphragm developed, so that these lungs are still simply enclosed by the abdominal parietes. The lungs of the chameleon are subdivided at their upper and back part, to a great degree of minuteness, into small cells, presenting at that part a very extensive surface for the distribution of the venous blood; but at the lower part of these large lungs you observe that that internal cellular structure has disappeared, and they are continued down over all the fore part of the abdominal viscera in the form of long detached saccular digitations, which form, in their interior, undivided continuous lengthened cells. Thus it is that the chameleon, by merely inspiring air, renders the whole trunk of its body, from the head to the rectum, turgid, round, and plump; and merely by a single expiration of air from these lungs, the whole trunk of the body (from being covered throughout the whole of this extent with ribs which in a singular manner continue across the fore part of the abdomen, and unite without extending forward to touch the short sternum) assumes a lank and lean appearance. It appears to be from this sudden change in its apparent condition of plumpness and leanness produced by simply inspiring and expiring air, that the poets represented it as feeding on air. This inflation of the body, by filling these long digitated lungs, appears to have very little to do with the changes of the surface of the skin, which are so remarkable and so useful for concealment in the chameleon. In this extension of the long detached cells of the lungs into the whole cavity of the abdomen in the chameleon, we see an analogy with the abdominal air-cells continued from the lungs of birds. We see here that the structure of the lungs in those slow-moving animals is such, that the whole cavity of the abdomen is filled, as in many birds, with isolated large cells continuous with those of the upper and dorsal part of the lungs. Those cells become collected together and further subdivided as we ascend to the highest class of vertebrata, until they are sufficiently concentrated into a more compact, defined, and circumscribed organ, to allow a muscular partition or diaphragm to be formed between the thorax which contains them, and the rest of the cavity of the trunk.

In the crocodiles and in the lizards the lungs are externally small, but are subdivided to a great degree of minuteness by internal partitions. They assume already that circumscribed form which is preparatory to the complete separation in the highest animals, by means of a diaphragm, between the cavity of the thorax and the cavity of the abdomen; and, indeed, a rudimentary condition of that diaphragm is already seen in these crocodiles and in birds, especially in the ostriches. We already perceive enlargements of the trachea, as in many birds. In the *gecko fimbriatus*, as in the emu of New Holland, there is a wide separation of the rings of the trachea, and a membranous portion, capable of distention, passing between the

widely separated ends of the rings, about the middle of the course of the trachea. The rings of the trachea are often complete, as in birds, and in some, as the iguana, the rings are deficient behind along the whole trachea. The branchial openings on the side of the neck, and the subdivision of the aortal trunk into lateral pairs of branchial arteries, have been seen and described by numerous observers in the embryo of the common *lacerta agilis*. Baer observed five pairs of branchial arteries. Three branchial openings on each side of the neck have been observed here, as in the serpents.

In the chelonian reptiles we observe, again, no muscular diaphragm separating a cavity containing the lungs from a general cavity of the abdomen, but that the lungs are equally developed, largely cellular, very capacious, and still composed of an undivided single distinct lobe upon each side. Those lobes are subdivided internally into very large cells, presenting thus but a small surface for the distribution of the blood, but admitting, especially in the turtles, a large quantity of air to be taken into their massive and heavy body. Those lungs extend backwards over the whole of the inner surface of the eight pairs of ribs that compose the carapace; so that the lungs are above all the abdominal viscera, they extend backwards even above the viscera of the pelvis; thus the turtles are supported in the water by great sacs of air in the position of the air-bag of fishes, but the cells of the lungs are enormously developed, contrasted with their general cavity. In many of those chelonian reptiles we see a very great advantage obtained by being able to receive a very large quantity of air, not subservient to respiration, into the cavity of their trunk. The heavy carcass of the turtle that sails by the slow motions of the arms through the deep, is greatly assisted in its movements by this large quantity of air taken into the cavity of the trunk. The body is thereby lightened, and this is required in these animals, where the muscular activity and force are comparatively feeble, and the respiration is comparatively limited. We perceive thus that there is not a direct ratio between the quantity of air that is taken into the interior of the body, and the extent of respiration in animals. By the extent of respiration of animals we mean, therefore, the extent of surface over which the blood of the pulmonary vessels is distributed, so as to come in contact with atmospheric air, so that the small but minutely subdivided cellular lungs of a rabbit present a much more extensive surface for the distribution of the venous blood over their interior than the enormous lungs of a turtle ten times its size. The quantity of air taken in by the quadruped is really less, but is all employed in aerating the blood; hence its high temperature activity and development.

We perceive also that for the evacuation of the contents of the intestine, and for the expulsion of the ova and other discharges, that this great capacity of the respiratory organs is important in the chelonia, where there is no motion whatever admitted of by the ribs, which are firmly united to the vertebræ, and to the sternum. And as the trunk is encompassed by an immoveable bony case, the parietes of the abdomen are thus aided by the lungs in the natural evacuations. As no motions here of the ribs give assistance in respiration, we observe that they are organized for that function nearly as frogs, that have no ribs whatever. The motion of inspiration is in both cases the same, both are employed in moving backwards and forwards the os hyoides, in drawing in the air through the nostrils, and in conveying it backwards by a kind of deglutition into the trachea. The trachea has here generally a lengthened form, and is surrounded as in birds with cartilaginous rings that completely encompass it. Sometimes the trachea divides near to its commencement at the larynx, and proceeds double, with those complete rings around it, to its termination in those great subdivided air-sacs on each side of the trunk. This structure of the trachea has relation to the pressure to which those air-tubes are constantly subjected while the animals retract the head beneath the ribs. In birds also, this solidity of the trachea appears to have relation to the very extensive and varied motions performed by the neck in that class of animals where the head is their only hand, and the neck their only arm, and by which motions the trachea might have its caliber diminished, were it not protected by complete rings, which are most frequently ossified.

The respiratory apparatus of birds is intermediate in form between that of reptiles and that of the mammalia. In the birds, as in insects, the respiratory organs extend through a great part of the body; the cells of the lungs have not yet been wholly collected into the anterior part of the trunk, so as to enable them to be commodiously placed in a cavity distinct from that of the other viscera, and separated by a muscular partition; but many of the cells of the lungs are here still continued into the cavity of the abdomen, and even

extend beyond the cavity of the trunk, as into the neck and the extremities. These numerous abdominal cells, consisting of folds of membrane highly vascular, formed by those ordinary cells of the lungs enlarged, supply the place of a mesentery before the abdominal viscera. Those cells, extending both forwards and backwards, are observed to open into the lower and posterior part of the lungs by a few large apertures, and to present internally septa partially dividing their cavity. One large cell extends forwards under the sternum, supplying with air the bones of the shoulder and arm; another extends to the vertebræ, another to the dorsal part of the trunk behind the heart and œsophagus, and others fill the abdomen and extend to the pelvis. The lungs of birds, like those of chelonia, are bound by cellular tissue to the inside of the ribs and the sides of the dorsal vertebræ, and there is therefore no distinct thoracic cavity, nor free muscular diaphragm. They consist of one undivided lobe upon each side, and are generally very light-coloured. The cells open directly from the bronchial trunks, and though minute, compared with those of reptiles, they are large compared with the cells of the lungs of quadrupeds. The trachea, which is here generally of great length, and surrounded with completely formed ossified rings throughout its whole extent, proceeds downwards along the side of the œsophagus into the dorsal part of the cavity of the trunk, where it forms the inferior larynx, and then suddenly bifurcates; from its bifurcation it immediately ramifies, thin and membranous, almost without bronchial rings, through the lungs. The trachea does not here continue to present those firm cartilaginous rings around it, after it passes into the wide cellular texture of the lungs; and this is connected with the fixed condition of the lungs and their want of division into distinct lobes, for we see in the mammalia, where the trachea subdivides into numerous large bronchi, and those bronchial trunks continue with their cartilaginous rings to a great degree of minuteness through the texture of the lungs, that the number of those great bronchial trunks corresponds with the subdivision of the lungs into lobes. The interior of the bones of birds, by communicating with the cells of the lungs, are respiratory organs, which communicate circuitously with the trachea, so that if we break the humerus and tie the trachea, the bird inspires and expires through the humerus. The cells, which are continued from the lungs into the general cavity of the abdomen, continue to the exterior of the trunk, appearing in the axillæ, in the neck, and in the region of the pelvis, so that the air has access to the long bones of the extremities, especially the humerus and the femur.

Birds, however, begin their career like reptiles, by having a spongy texture of the interior of their bones filled with a thin marrow, and even the rapacious birds begin in the same manner with marrow, and not air, in their bones. The air in them soon gains access at the proximal extremities of those bones from the air-cells extending from the lungs, and in proportion as the air extends into the interior of the bones the thin serous marrow is absorbed and displaced, and its situation is occupied by the air taken in through the lungs. This proceeds to a very variable extent in the different orders of birds. There are some which pass the greater portion of their life swimming on the dense surface of the water, and these heavy aquatic birds require not that light skeleton made almost entirely of thin air-tubes, such as we see in these eagles, hawks, and other diurnal rapacious birds. The swimming birds are destined to retain the embryo condition of their bones through life, filled with a thin marrow but in the high-flying rapacious birds, the air is passed to so great an extent through all the solid parts of their skeleton, that almost all the bones are light air-tubes; they are condensing syringes, into which the air can be forced by pressure of the abdominal parietes upon the cells, and the air thus condensed in those tubes facilitates the descent of the bird through the air when pouncing upon its prey.

The inferior part of the trachea in birds is formed into what is called the inferior larynx. That is composed of enlarged tracheal rings, which have more or less metamorphosed their form, and the muscles which move this remarkably developed part in birds are found in a less conspicuous form in the same situation in mammalia as shown by many anatomists. The superior larynx is still very simple in its structure, and the epiglottis is seen only in a rudimentary state in a few of the birds which approach nearest to the mammalia. The muscular diaphragm, which separates the thoracic cavity from the abdominal in mammalia, is seen only in a very rudimentary condition in birds in the form of small muscular bands which shoot upwards from the ribs over the surface of the lungs, aiding but slightly in inspiration, and developing thus from the periphery towards the centre, like the diaphragm in the embryo of quadrupeds. This muscular partition is developed to the greatest extent in the ostrich, a bird which is full of analogies with the mam-

malia in other parts of its structure, but the lungs themselves of these struthious birds are smaller in proportion than they are in the long-winded singing tribes, where they are most capacious. The sudden divisions of the bronchi in birds, and their abrupt termination in large cells, approach their lungs to those of tortoises, turtles, and many other reptiles.

Now before the branchial openings are developed on the sides of the neck in birds, the integuments appear entire on each side, and when the embryo is more developed, three lateral passages are discovered on each side leading into the throat. They are seen in the chick on the third day of incubation, and they continue open to the eighth. There are distinctly five pairs of branchial arteries, which receive the whole contents of the aorta, but the aorta is seen here to divide from its origin into two trunks, each of which gives off the five branchial arteries of its own side. Between the second and third days of incubation, four pairs of these branchial arteries are observed to be successively produced from before backwards, and the first or anterior of these pairs has disappeared before the fifth pair is developed behind on the fifth day of incubation. The same order of succession is observed in the development of the pairs of branchial apertures from the anterior to the posterior pairs.

The respiration of quadrupeds is more confined to the lungs, and is less extended through the system, than in birds, and though their lungs are proportionally less capacious than in many reptiles or in birds, these cavities present an immense surface, from their minute subdivision into cells. Here the muscular partition formed between the two great cavities of the trunk by the diaphragm is completed, and the lungs float freely in a distinct cavity of the thorax, for the first time, in this class. They here send down no cells into the cavity of the abdomen, so as to fix them to that cavity; they here send out no membranous tubes to continue into the bones; they are, therefore, concentrated within the thoracic cavity, along with that organ which is always in proximity to the respiratory organs — the heart. Those respiratory organs are greatly developed in all the more powerful mammalia, as in the carnivorous quadrupeds; but they are comparatively smaller in their extent of surface in the slow and feeble and inferiorly organized herbivora. This extent of respiratory surface is seen in the minuteness of the cellular and lobular subdivisions of the lungs, as well as in their outward dimensions, the subdivisions of the lobes of the lungs, as of several other organs, being greater in these quickly-moving, strong, and muscular quadrupeds, than in the more simply organized vegetable-eating tribes. The varieties of these organs presented by the different orders of quadrupeds relate chiefly to their exterior divisions, and to their greater or less capacity, the plan of structure being nearly the same.

We see in the diving quadrupeds, as in the beavers and the seals, that the nostrils are protected by valvular structures from the water through which they move with rapidity. We see a somewhat similar structure again in the cetaceous animals, although the form there is different. In the porpoise, and several others, the nostrils are lengthened out into two sacs of considerable length, muscularity, and mobility, as in some of the allied crocodilian reptiles, by extending which to the surface of the water, they can respire air freely, while all the rest of their body is under the surface. The trachea is here comparatively short and straight, and of equal caliber, directed a little to the right of the œsophagus, and with the cartilaginous rings incomplete behind. It divides and subdivides before entering the substance of the lungs, and continues its cartilaginous rings through the minute subdivisions of the bronchi. The primary divisions correspond with the number of the lobes, which, from the sinistral position of the heart, are more numerous on the right than on the left side. The development of these respiratory organs of the mammalia and of the branchial arteries and apertures, presents nearly the same phenomena as in the inferior air-breathing vertebrated classes, and these branchial apertures on each side of the human neck have been already often observed and described by anatomists, as by Rathke, Baer, Ascherson, Burdach, Meckel, Muller, and many others. There are generally three of these branchial openings present at the same time on each side of the neck, as in the embryos of inferior pulmonated vertebrata; these appear in succession from before backwards, and the anterior openings on each side are generally much larger than the two posterior. In a human embryo, three lines long, Rathke found them not yet opened. Four pairs of these openings have been observed present at the same time, both by Muller and Burdach in the human embryo about the fourth week; and Ascherson has observed and described several cases where remnants of these branchial openings were preserved through life, forming congenital fistulæ in the human neck. Thus we ob-

serve that there is great uniformity of plan in the development of these parts in the vertebrated tribes, and a beautiful adaptation in all the forms of the respiratory organs to the living conditions of animals and the place they occupy in the scale of beings.

LECTURE LII.

ON THE SECRETING ORGANS OF ANIMALS.

The blood, replenished with fresh materials from the lacteals, and oxygenated by respiration, is fitted to be sent through the system for the nourishment of all the organs, and to afford the materials of all the secretions. But every living membrane in contact with a fluid, whether on the surface or in the interior of the body, exhales its own peculiar secretions; and in the lowest tribes of animals all the requisite secretions are furnished, often without the presence of a sanguiferous system. The materials thus transuded through the porous texture of membranes, or the parietes of capillary vessels, are sometimes destined to form a part of the system, sometimes to assist in the assimilation of foreign matter, and sometimes to form excretions to be discharged from the body. These secretions are not mere transudations of materials, unchanged in composition, from the fluids which afforded them; they are generally altered both in their chemical and physical properties by this transmission. They are poured out alike by the cutaneous covering of the surface, and by its continuation the alimentary canal, or into the shut cavities of serous membranes; but it is not yet distinctly ascertained how far the peculiarities of the various secretions are due to the form and texture of the membranes which afford them, or to the mode of distribution of the vessels, or to nervous influence. The secerning membranes most frequently present a tubular form, open at one end and closed at the other, forming sacs, or follicles, or conglobate or conglomerate glands, and their whole form and structure become more complicated as the fluids they produce differ more from the ordinary fluids of the body.

The intestinal canal, itself a secreting surface, is the common sewer of the body into which numerous streams of secreted fluids are incessantly pouring from all sides. Most of the secretions poured into this canal are chylopoietic, or assist in the conversion of the food into chyle, to replenish the blood. The glands thus subservient to nutrition, and even to the formation of the globules of the blood, are the most essential to life and growth, and the most universal in their occurrence in the animal kingdom. Indeed the processes, of nutrition and growth may be considered as a series of secretions performed by all living organized beings, though not produced by distinct glands. The first formed secreting surface is the skin, and next to this is its continuation, the intestine; but a mucous membrane, a mucous follicle, and a muciparous gland, are but different forms of the same surface, more or less isolated, and more or less complicated. It is only when these secreting surfaces have assumed an isolated form, that they have received the name of *glands*, which may thus be developed as isolated cæca, or sacculated recesses, from every surface of the body. Most are developed from the inner surface, and all glands in their lowest permanent forms, and in the first stages of their development, where they arrive at more complicated forms, are simple cæca prolonged from the surface on which they open. Now you will observe, that the transition from secreting, lining, or investing membranes, to secreting glands, is quite imperceptible and gradual, and the most complicated glands of the highest animals, as the liver and the pancreas, scarcely merit the name of glands in their primitive conditions of development, and in the lowest tribes of animals. The duct of a gland is the gland itself, and it may be a simple undivided follicle, or it may be ramified to infinity, and compose a large conglomerate mass; but this membranous duct, with its vessels and nerves, appear to be alone essential to the secretions. The liver and the pancreas are but ducts developed from the intestine, and ramified to a great degree of minuteness; but we cannot perceive any necessary connexion between the forms of these ramifications, and the properties of the fluids which they produce. The mode of subdivision of the duct, and the mode of distribution of the bloodvessels and nerves, are peculiar in each gland, and these are no doubt connected with, or determine the peculiarities of, the secretions. The intimate structure of all glands, so far as we can perceive it, being thus very simple and very similar, the study of these organs relates chiefly to differences in their forms and products throughout the animal kingdom.

As the function of digestion is the most important in the process of nutrition, and the most universal in animals, we find the glands connected with this function the most developed in the highest animals, and those which we perceive first in the lowest tribes. We see the digestive ne-

tion effected in many of the lowest animals, without the aid of distinct glandular apparatus to pour into the alimentary cavity peculiar fluids or secretions, but we see in all the more complex animals that numerous secretions are poured into that alimentary canal, to assist in the process of assimilation. Now the chylopoietic gland which appears the most constant in the animal kingdom, and the most important in the process of digestion, is the liver. That gland, which is so enormous and so complicated in the mammalia, we find continued downwards through all the vertebrated classes of animals, through all the molluscous and most of the articulated classes, and even making its appearance among the animals of the last division, the radiated or cycloneurose classes.

In the polygastric animalcules we see no part developed from their capacious alimentary canal, excepting those sacs into which their food is conveyed, that we could consider as analogous to a secreting gland; and if we did discover such development, there would be every reason from analogy to consider that that little glandular follicle, or chylopoietic secreting sac, first developed and opening into their wide intestine, was the analogue of the human liver. That conclusion we would come to from observing, that in tracing downwards the glandular organs in the animal kingdom, we gradually lose all the other glands before we find the liver to disappear, and, therefore, the first gland which makes its appearance in ascending may be regarded as a rudiment of that largest, most important, and most constant chylopoietic gland. The numerous intestinal cæca or stomachs of these animalcules have some resemblance to the hepatic cæcæ developed from the sides of the intestine of annelides. They often swallow prey ten times the size of their little cæca or stomachs, and while the whole granular contents of their capacious middle cavity are constantly revolving in a circular manner, backwards on the dorsal side, and forwards on the ventral side of their body, the little cæca retain their respective places. This internal cyclosis, resembling that of the cell of a chara, and probably produced by internal cilia in the intestine of animalcules, is very obvious in the common large *paramæcium chrysalis*, so that the cæca of polygastrica may also be analogous in function to those hepatic cæca of the higher helminthoid classes. They are sometimes driven to and fro in the great abdominal cavity of the *paramæcium*, like loose balls in a sac, especially when the animalcule is struggling to force its body through a narrow passage. Sometimes they are all forced to the anterior part of the body for an instant, then hurried in a mass to the posterior end, or spread through the general cavity, and we often witness a large round cæcum suddenly contract and disappear where it was alone, and distinctly seen, in the transparent texture, which is probably caused by its suddenly emptying its contents into the general cavity of the body, where there is a constant slow revolution of all the granular particles. Notwithstanding the extraordinary mobility of these round cæca in the general cavity, they are not carried round the body with the other moving particles in the constant circulation observed in the whole abdomen when the animalcule is at rest.

We see in some of the calcareous zoophytes, as the flustræ, that there opens from the side of the stomach of the polypus a small cæcum, which is sometimes seen empty, and sometimes filled with opaque matter, like the stomachs of polygastric animalcules. If this small cæcal appendix, developed from the side of the stomach of the polypus, is to be regarded as a glandular or secreting organ, it presents the simplest form of the liver, as that is found to be the first gland developed from the intestine of animals. This is the mode in which the liver begins its development in higher animals. Eschscholtz ascribes this gland to the medusa and to the rhizostoma. The small cæca, sometimes ramified, which are seen opening into the intestine of holothuriæ and the stomach of stellerida, are, according to Chiaje, conditions of this organ among the echinoderma, but the ends of the intestinal cæca more probably are the analogues of the liver. In the higher entozoa, as also in many of the annelides, this organ consists of innumerable small and short cæca, which surround closely the intestine, and open into its cavity. This gland is given to the entozoa by Rudolphi and Bojanus. In the rotiferous animals, two small glandular sacs open by two short ducts into the masticating cavity, surrounded with muscles, and provided with teeth. This masticating apparatus much resembles the stomach of crustaceous animals, with its muscular strong, parietes, and contained teeth, and is generally withdrawn to a great extent within the anterior part of the body when food is seized. As this masticating organ performs the functions both of mouth and stomach, these two glandular sacs which open into it may be considered as analogous either to the liver, or the salivary glands, or the pancreas, or to the whole of these organs. In the cirrhopods, the liver embraces the stomach with its numerous small lobes, and consists of innumerable ramified

cryptæ or follicles, which open by short and wide ducts in several parts of the parietes of that cavity, an affinity which those animals present in this organ to its form and condition in the molluscous classes. Numerous cæca are seen extending from the sides of the intestine of many of the annelides, which sometimes enlarge into sacs, or ramify at their free extremities, and generally contain a yellowish-white matter. These small appendices present the most divided form of the liver met with in the articulated classes, in so far as relates to its openings into the alimentary cavity, but not as relates to its extent of ramification, which appears to be greatest in the crustacea. The biliary sacs are simple and undivided in the *halithea*, as in the polygastrica, but ramified in the planariæ. In the myriapods, as in insects, the biliary organs have a lengthened tubular form, and in the arachnida and crustacea they present a more ramified and divided form, with the component cæca generally composing distinct lobes.

In the class of insects we observe the whole apparatus of digestion arrived at a high degree of complexness. We see there not only a biliary secreting apparatus, but also distinct pancreatic glands. We see salivary glands also contributing to assist in the process of digestion, and corresponding with the development of the masticating organs. Here the secreting organs of the bile are in the form of tubes, sometimes simple, that continue from the sides of the intestine, and form innumerable convolutions, filling a great part of the cavity of the abdomen, and returning again into the intestine. Those numerous convolutions of the biliary glands or the liver of insects form lobular masses, which surround the alimentary canal, but which we can easily with a little care uncoil, and observe that they form a continuous tube. A more complex form of this gland we see in insects which feed upon vegetable substances, the simplest form of the tube without lateral prolongations, being that which is most common in carnivorous insects, as in the *cincindela*. In those that feed on vegetable substances, as in this *melolontha*, we generally observe developed from the sides of those convoluted biliary tubes, innumerable very small cæca, presenting thus a very large secreting surface, with the tubes themselves for pouring the fluid into the alimentary canal. This is a character which we observe, with certain modifications, throughout the articulated classes of animals, with articulated members. We observe, numerous lobes formed by those cæca in the crustaceous animals, the lobes consisting entirely of the subdivisions of those numerous biliary or hepatic ducts. Here, however, in the crustacea, we observe that they have ramifications very different from those which they present in the class of insects; that the trunks subdivide immediately from their origin, and those subdivisions again quickly divide into an infinity of smaller divisions, which all terminate by their round, shut extremities on the surface of all the lobes. Those great trunks form the radicals of the several lobes, and thus we observe the origin of this lobed appearance of the liver in the crustacea, and in various other glands of higher animals. Upon removing the peritoneal covering from the surface of the liver in the crustacea, and floating the liver itself gently in water, we can perceive distinctly, separating from each other, the numerous small cæca that compose the lobes; they are filled here with a yellowish turbid secretion, which is poured from the small subdivisions of those ramified ducts into larger and larger trunks upon each side, until the whole unite into two trunks that open at the pyloric extremity of the stomach.

In the molluscous classes of animals we observe that this organ also preserves constantly a proximity to the stomach, and is perhaps deficient only in some of the lowest of the tunicata. In the tunicated animals we observe that the pyloric extremity of the stomach is surrounded by distinct lobes, which we cannot, without cutting the ducts, dissect off from their contact with the surface of the stomach. An enlargement of the biliary ducts, forming a gall-bladder, is ascribed to the *salpa*. In the *ascidiæ* and several of those more complex genera of the tunicated animals, this biliary secreting organ is generally divided into distinct lobes; those lobes consist, in the same manner as in the crustacea, of the subdivisions of the hepatic ducts covered by the thin peritoneal membrane. Upon opening the stomach, we perceive the large apertures by which those cæca or biliary follicles open into the cavity of that organ; those large openings are the short hepatic ducts, and this is precisely the structure which we see in the conchiferous animals. In all the molluscous classes of animals, the liver is generally of great magnitude. It is that gland by the secretion of which the process of digestion is greatly aided in these vegetable-consuming classes, where the salivary and the pancreatic glands have scarcely a development till we arrive at the higher classes of the mollusca. We observe that in the conchiferous animals, the lobes of the liver surround the pyloric portion of the stomach, as in the tunicata; and that, upon opening the stomach, the

large apertures are seen leading directly into the interior of those ramified cæca composing the lobes of the liver. The apertures by which these short hepatic ducts terminate in the stomach, have generally an oblique direction. When we open, however, the cavity of the stomach, we can see, without dissection, the numerous oblique wide lateral passages leading into the subdivisions of the liver. It often envelops also the turns of the intestine, and probably pours its secretion also into that part of the alimentary cavity.

In the gasteropods we observe the liver generally of great magnitude, and that it still opens, as in the acephalous mollusca, into the cavity of the stomach. It opens into the cavity of the stomach at its pyloric extremity; and we have it there opening close to the orifice of another little gland, a small, simple, and distinct glandular cæcum, the obvious rudiment of the pancreatic gland, the constant concomitant of the liver. The liver here also generally envelops a large portion of the intestine, with its numerous lobes, as in the conchifera.

In the pteropods the liver presents still the same character. We perceive that in the clio, the lobes of the liver envelop almost the whole length of the stomach of that animal, those lobes sending their ducts directly into the cavity of the stomach. In the cephalopods we observe the liver of great magnitude, occupying generally the upper and dorsal part of the cavity of the mantle. The liver has here generally a dark-brown colour, which results from the hue of the secretion that is formed by the parietes of innumerable cæca, which compose the entire mass of the organ. We find the biliary secretion to have this turbid yellowish-brown colour throughout all the cæca, and throughout the ducts to their termination in the spiral or third stomach. Upon removing the outer peritoneal covering from the liver of the sepia or the loligo, and slightly detaching the cellular tissue and vessels which connect the cæca together, we can easily perceive, by floating them in the water, the loose terminations of the innumerable separate peripheral cæca, in which the biliary ducts ultimately terminate, when we trace them from their trunks to their ramified terminations. The whole of this large orange-coloured mass consists only of a myriad of ramifications of the hepatic duct. At the lower and fore part of the liver two ducts issue. These two ducts convey the secretion of all the innumerable cæca downwards to near the spiral stomach, where they unite into a single duct. This duct terminates in the spiral stomach by a single oblique valvular orifice—an orifice where you observe that the duct, formed by the junction of the two hepatic ducts, not only enters obliquely, but has at its entrance two thickened lateral folds, that serve as a valve to prevent the partially-digested food contained in this spiral stomach from passing upwards through the long hepatic ducts. This is a more isolated and concentrated form of the liver than we see in any of the inferior classes. We still see, even in these molluscous classes, very obviously the true origin and nature of the liver, that it is merely a continuation of the digestive canal, a ramified appendix, continued from the alimentary cavity, like the cæca of animalcules; but here it is become at length more isolated in its form, and even presents a valvular structure placed at its termination in the alimentary canal, as we see in higher classes. Around these minute component cæca of the liver, the hepatic arteries are minutely distributed to afford the materials of the bile which transudes from their parietes.

In fishes we find the liver generally of a large size, as in the mollusca, of a very light colour, of a soft consistence, divided into numerous lobes, and abounding with an oily secretion. A part of the duct is developed generally into a gall-bladder in the class of fishes, in addition to the mere cæca, which we perceive to constitute the liver in the inferior classes. The hepatic duct, after having received the secretion of all the different minute cæca, here commonly forms an enlargement in its course,—a gall-bladder, which is seldom wanting in fishes, and is generally large. At first a simple enlargement, or small cæcum, opening obliquely into the side of the hepatic duct, enlarges, becomes more isolated, and has a lengthened duct for itself to communicate with the hepatic, and the junction of these forms the ductus communis choledochus; but observing the origin of the liver itself, and the means by which it is rendered thus complex, we have no difficulty in perceiving the true nature and the origin of this reservoir for holding the secreted fluid until it is needed. Hence it is, that in the predaceous and carnivorous animals, where the food is obtained often at long intervals, this reservoir is of great utility. It receives the bile that is pouring down in such animals, by the incessant secretion from the minute cæca of the hepatic ducts; as the circulation is going on incessantly through those capillary vessels, so the secretion is constantly forming. But it is most wanted in animals when the food is there to be acted upon by it, and as many animals feed upon vegetable substances,

of which there is an unceasing abundance on the face of the earth, those animals require no gall-bladder or reservoir, but a constant direct supply of bile, and are not subjected to those long fastings and gormandizings which the carnivorous and rapacious animals are subject to. Hence it is, that in these carnivorous classes of animals, the reptiles for instance, the greater number of which are predaceous, we find that the gall-bladder is remarkable for its constancy; that in other classes and orders of animals, where the disposition and habits, as relates to food, are very dissimilar, one genus has that appendix, that reservoir or cæcum, the gall-bladder, developed, while the next genus, with different habits, is totally destitute of such an organ.

In the class of fishes we observe a great variety in the outward form and size of this organ, which differences are of less importance, as they merely arise from its being cleft into a greater or less number of lobes or marginal divisions. We find here, however, that the internal structure of the liver, in a more important part, is becoming different. In the cephalopods a branch of the aorta, as that trunk ascends behind the liver to the head, comes off, and is distributed on the interior of that organ—the hepatic artery. We perceive as yet no trace of a portal vein. By this artery all the materials are afforded for the secretion of the contents of all those small hepatic cæca. As we ascend, however, through the fishes, we see that the blood which has been sent through the muscular and the digestive organs is collected by the veins, and sent again, by those veins accumulating into a vena portæ, through the liver. Those portal vessels are less subdivided through the liver in the class of fishes than in higher vertebrata; they become more and more subdivided through that organ as we ascend to the mammalia. It is seen by their trunks passing more directly through the substance of the liver into the hepatic veins, and not ramifying to infinity as in the mammalia and in birds. There are frequently hepato-cystic ducts in fishes, which conduct the bile directly from the liver into the fundus of the gall-bladder, as well as the usual hepatic ducts leading to the cystic. The bile in fishes is poured by the ductus communis choledochus into that part of the duodenum that is immediately behind the pyloric valve; it is poured into the intestine in close proximity to the secretion of another glandular organ, which presents nearly all the different phases of its development in the single class of fishes—the pancreas.

In the amphibious animals we observe the liver for the most part of great size, and partially divided into two lobes. This we find also through the different orders of reptiles. The structure of the organ here is nearly the same as that of fishes, and there is almost always a large gall-bladder, as in that class. The hepatic ducts that constitute the essential part of the liver vary much in their mode of ramifying in the vertebrated classes, and in the mode of grouping of their minute lobules or acini, as observed by many of the older anatomists, and especially by Malpighi. The development of the liver has been traced by Muller in the tadpole, and observed to commence by a few small and simple follicles, which increase in number and length, and ramify to compose the large-lobed organ of the adult animal. In the *pipa* three of the original divisions of the organ remain permanently detached, forming three distinct and separate lobes. In the true reptiles, the liver is more minutely subdivided into acini and their component follicles, the portal circulation is more complete, the organ is large, and little divided externally into lobes. The gall-bladder is seldom wanting in this class, and there are commonly hepatic ducts passing directly from the liver to the duodenum, besides the duct from the gall-bladder. The organ is remarkably lengthened in the ophidian reptiles, broad in the chelonia, and of an intermediate form in the saurian animals. In the ophidia the hepatic ducts alternate with the separate pancreatic ducts in their points of entrance into the duodenum. There is still a separate hepatic duct in the class of birds, which passes into the duodenum above the entrance of the cystic, and the whole product of the liver is here poured into the intestine at a considerable distance below the pyloric orifice of the stomach. The secretion of this organ, which we saw in the lowest animals poured directly into the stomach, to reach the food early, and to act upon it during the whole of its short passage through the body, now enters the alimentary canal at a distance beyond the stomach, the food being here acted upon by other secretions, and having a long course to pass through after leaving the stomach. The fundus of the gall-bladder still often receives several hepato-cystic ducts, as in lower classes.

The intimate structure of the liver in the highest class of animals still presents an obvious appearance of minute cæca, forming lobules, by their grouping, when we examine it upon the outer surface through the transparent peritoneal covering, or even when we cut open the trunks of the great vessels, the vena portæ, or the large hepatic veins. This minute lobulated ap-

pearance is produced, as shown by MALPIGHI more than a century past, by the ramifications of the hepatic duct, which here branches generally into leaf-like groups of terminal follicles, seen every where over the surface, and through the interior of the mass. Into these minute terminal follicles and their connecting trunks the bile is transuded from the capillaries of the previously united vena portæ and hepatic artery. But although these follicles vary in their minuteness, and in their mode of grouping into lobules or acini, in each of the mammalia, and also in the mode of distribution of the bloodvessels through the mass, we still observe this largest and most complicated gland of the body to consist, in the highest animals as in the lowest, merely of a membranous duct, or prolongation developed from the parietes of the alimentary canal. From the chemical composition of its products, this organ performs a function somewhat similar to the lungs, and we find it developed in animals, generally in the inverse ratio of their respiratory organs.

Other important glandular organs pour their secretions into the alimentary canal, as the pancreas and the salivary glands, and these pass through nearly the same varieties of form, as we have seen in the liver, during their development, and present corresponding phases of development in the permanent forms which they exhibit in the lower animals. As low as the class of insects, we perceive other distinct glandular cæca developed from the side of the intestine near to the hepatic vessels. From its proximity to the liver, and its still rudimentary condition, the nature of that gland cannot be mistaken. It is of a form still more rudimentary, still more simple, than that presented by the liver itself, having generally the appearance of a small short simple cæcum. That is a rudimentary form of the pancreas which belongs to some of the articulated, and also of the molluscous animals.

We observe the pancreas to present in the gasteropods the same form. It there appears, as in the doris and in the aplysia, as a small simple cæcum, with cellular thick parietes, pouring its secretion into the cavity of the stomach at its pyloric extremity, close to the openings of the hepatic ducts. In many of the cephalopods we observe, surrounding the hepatic ducts, numerous small glandular subdivided or cellular follicles, that pour their secretion into the two hepatic ducts by small tubular short peduncles; those glands, from their communicating with the hepatic organs, and pouring their secretion into the same point of the alimentary canal with the biliary ducts, can scarcely be considered as the analogue of any other organ than the pancreas. In the loligopsis, those glands have a more ramified form than they have in the sepia or in the loligo. They have here the form of tufts, and those tufts shoot out, forming distinct lobes in that small animal; so that this gland has the same proximity to the liver, when present in the invertebrata, as in the vertebrated classes.

In the class of fishes we observe the pancreas to have its simplest form in the osseous fishes, where it has the form generally of numerous detached cæca of considerable size, opening, by many distinct orifices, into the commencement of the duodenum immediately beyond the pyloric valve. In the frog-fish, the *lophius*, two only of those pyloric or pancreatic cæca exist, which are short and wide, one a little larger than the other. These open immediately beyond the pyloric valve, and close to the termination of the ductus communis choledochus, showing obviously the nature of those small glandular cæca. In the cod, the haddock, and most of the osseous fishes, we observe that they are much more numerous, surrounding, by their numbers, the whole of this portion of the duodenum immediately beyond that circular projecting internal fold of the mucous coat called the pyloric valve. Frequently, however, we can perceive that those cæca divide and ramify at their distal extremity, each minute division presenting its shut extremity around the exterior surface of the organ. Sometimes these extreme divisions unite to form a few large trunks, which open by a single orifice into the duodenum. That is the ramified structure we observe in the pancreas of the *xiphias*, but to a much greater extent. This minute subdivision of the organ is seen also in the sturgeon. This condition of the pancreas is an approach to the more complex conglomerate form of the gland which you see in sharks and rays and other cartilaginous fishes, where it becomes so minutely ramified and complex as to give it the distinct conglomerate form. That is the form it presents in all the higher classes of vertebrata, in amphibia, reptiles, birds, and mammalia. It differs in those classes chiefly in those less important circumstances of the number and form of its outward divisions, which it manifests upon its exterior surface.

Its trunks continue subdivided from their origin, so as to form detached groups of ramifications in the ophidian reptiles, constituting distinct lobes, and each of those terminates in the duodenum by a distinct pancreatic duct, which shows you

that there is still a remnant in these reptiles of the character which this gland so commonly presents in the class of fishes, where each simple division of the organ opens, in the form of a separate cæcum, into the intestine by a distinct orifice. Even in birds, where the pancreas is large, from the imperfect salivation of the food, there are frequently several pancreatic ducts arising from distinct lobes that open, alternately with the hepatic ducts, or above them, into the cavity of the duodenum. In the struthious birds, which come nearest to the mammalia, there is but one pancreatic duct, as in the class of quadrupeds, and there are generally three in the rapacious birds. The division of the pancreas into two lobes continues perceptible through most of the mammalia, and these are seen through the peritoneal coat to be composed of smaller lobules, or groups of minute ramified and convoluted cæca, which are the extreme terminations of the duct developed originally from the intestine.

The salivary glands, so important in all masticating animals, commence their career of development as simple undivided minute cæca, or glandular tubes, developed from the sides of the mouth or œsophagus in the lowest tribes of animals; and as we advance to higher classes, we find them gradually assuming a more ramified and complicated structure, and greater dimensions, their forms and conditions still varying with the kinds of food, and the living habits of the animals. They are already assigned by TIEDEMANN to the holothuriæ, by CHIAJE to the nereis, and by BRANDT to the leech, but they are often obvious in insects as two lengthened glandular tubes opening into the sides of the mouth, as shown by DUFOUR in the dipterous insects. They are almost entirely deficient in the toothless acephalous mollusca, but are found of a simple form and structure in the brachiopodous conchifera, as the *lingula* and *terebratula*. They form large conglomerate and often lobed glands, with long ducts, in most of the gasteropods, and also in the cephalopods, while the pteropods and some of the inferior gasteropods have the salivary glands in the form of simple lengthened tubes, as they occur in insects. When in their most conglomerate form, as in the gasteropods and the cephalopods, there are generally distinct lobes which send out separate ducts to terminate in the mouth, and sometimes they are unsymmetrically developed on the two sides, or even entirely wanting. Fishes, which little require such a fluid as saliva in the mouth, have the place of the salivary glands supplied by enlarged mucous glands, which pour out a copious secretion into that cavity, and the same is the case with most of the amphibia and with many of saurian and chelonian reptiles, but they are large and the salivary secretion is copious in the serpents. They are very rudimentary in the aquatic birds, but we commonly find four pairs of these glands in various conditions of development in the higher orders, and they present corresponding varieties in the class mammalia, according to the aquatic or terrestrial habits, or the kind of food of these animals.

LECTURE LIII.

ON THE SECRETING AND LYMPHATIC SYSTEMS OF ANIMALS.

THERE are numerous glands in animals destined to form important secretions from the blood, though not subservient to nutrition, or more remotely connected with the process of assimilation, than the great chylopoietic glands, the liver, the pancreas, and the salivary glands, we were examining yesterday. They still present mere membranous sacs more or less divided, and more or less isolated from the surface on which they open. In each we observe a peculiar mode of distribution in the bloodvessels which bring the materials of the secretion to the gland, and in the nervous filaments, which, like electrical wires, determine the affinities by which the secretion is produced, and also in the mode and the extent of subdivision of the membranous cæca, through the parietes of which the secretions transude from the capillary bloodvessels. There are glands in every condition of complexness or development, even in the highest animals, from the simplest isolated mucous follicles to the most conglomerate form of the liver and the salivary glands; and we find already, in very low invertebrated animals, many glands arrived at a most conglomerated structure, but the general plan of development is the same in every gland, traced through all its varieties of form. The plan of internal structure being thus so uniform throughout the whole series of these secreting or glandular organs, we may consider their various forms and uses in systematic order, as they present themselves in ascending through the different classes successively, from the polygastric animalcules to man.

We observe no distinct glandular organs in the polygastric animalcules, but their outer surface, as well as the parietes of their internal canal, and the parietes of the various stomachs or cæca, which are

developed like biliary follicles from the sides of that capacious internal canal, no doubt possess a power of secretion as well as of absorption, like other membranous parts. Distinct glandular organs, however, adapted solely for some particular kind of secretion, have not been discovered either in these polygastrica or in the poriferous animals. In both we perceive only an extension of the general cutaneous and intestinal mucous and absorbent surfaces. Many of the polygastrica, and of all the other radiated classes, have been observed to emit a bright luminous appearance when irritated, which has been ascribed to the mucous secretion of their surface.

Among the polypiferous animals, we have seen that already the liver makes its appearance in the flustræ, as a small appendix or single follicle extending from the alimentary cavity. We observe in those animals the power of secreting from their surface, by their pouring forth large quantities of earthy matter, for the most part of the carbonate of lime, with a little of the phosphate, mixed with a coagulating muco-gelatinous substance; while others secrete upon their surface, or into their interior, a soft homogeneous coagulable substance, which soon hardens to form a skeleton of a horny nature. We perceive, however, no distinct glandular apparatus for elaborating those materials from the food which they take in. We observe that each species of those animals develops the gemmules always from a particular point of the body, and that they do not bud out indiscriminately from every part of the fleshy substance. We may consider, therefore, that the ovarium or the gland for secreting ova, which is developed in higher classes of animals, presents itself here in a rudimentary state, as a gemmiparous point of the fleshy substance. Many secrete colouring matter of various hues, sometimes along with the earthy matter, as *corallium*, *tubipora*, *melitæa*, and sometimes without it, as *actiniæ* and *zoanthi*. Some of those animals, as the *pennatulæ*, have a power of producing, apparently by means of secretion, very brilliant luminous appearances when they are excited or alarmed. They secrete upon their surface, as we see also detached in flocculi from the surface and from the canals of porifera, a thin mucous film, which is frequently and periodically cast off. We may regard the glandular organs of these lowest classes as in their simplest condition of flat smooth secreting membranes, which have not yet developed even cryptæ or follicles for the different kinds of products. The surface of the stomach in the *actiniæ* produces a copious secretion, which appears to prove quickly fatal to the animals taken into that cavity to be consumed.

Many of the acalepha, especially of the minuter forms, as equoreæ and beroes, are observed to emit a brilliant light, probably the result of some secretion formed with a view to self-defence, but the particular parts by which that luminosity is produced, and the nature even of that luminosity, are alike unknown. They are considered by CHIAJE as produced by a fluid secreted on the surface. The greater number of those soft gelatinous animals secrete a substance on the surface of their body, and which appears to be generally diffused over every part of the surface, which is of a very poisonous and stinging quality. This in all probability is likewise designed as a means of self-defence. It is remarkable for its irritating effects on the human skin, often exciting inflamed spots or a diffused acute inflammation over the more delicate parts of the skin which have been touched. Some, we have seen, secrete a firm cartilaginous internal axis, and many, as the *physaliæ*, secrete a gaseous fluid into a distinct sac, to enable them to float at the surface of the water. Some secrete a bright blood-red matter in their long tentacula, and the *velellæ* are covered with a substance of a deep violet-blue colour. The marginal, cylindrical, opaque, granular bodies of many *medusæ* are regarded as the liver.

In the echinoderma we observe numerous distinct matters to be separated from the food by the vital processes of the animals, but few secreting organs appropriated to their formation; the various colouring matters of the surface, the numerous forms of calcareous deposits, the secretions of the alimentary cavity, the copious mucous secretions on the surface of the *holothuriæ* and other naked species, the supposed calcifiant gland of the stellerida, which is a small vascular sac containing a thick grumous calcareous secretion.

In the entozoa, besides the liver, the ovaries, and the testes, we scarcely observe traces of any distinct glands, either connected with individual nutrition or with generation. In the rotiferous animalcules we observe two oblong glandular sacs, which appear to open into the back part of the mouth by short narrow ducts. Those organs are regarded by some as the pancreas, and from opening into this muscular sac, like the stomach of a crustaceous animal, they might be the rudiments of a liver in this class of animals, notwithstanding their elevated position towards the commencement of the digestive canal; because we see, on passing downwards from man, that the great secreting chylopoietic organs, the liver and the pan-

creas, ascend in regard to the point of the alimentary canal into which they pour their secretions. It is in the highest class of animals that we see those secretions poured into the part of the alimentary canal most distant from the mouth and from the stomach; but as we descend from man, these secretions approach nearer and nearer to the stomach, until in the molluscous and the articulated classes of animals they are actually poured into the stomach itself. Thus, passing still lower downwards in the scale, we should expect that those secretions formed by cæca which compose the liver, should be poured into a situation even higher than the stomach itself. In those rotiferous animals we also observe, besides the generative glands terminating in the cloaca, numerous long and wide cæcal appendices and tubular filaments extending from the sides of the intestine. In the cirrhopods we observe, besides the liver already largely developed, and two conglomerate salivary glands, and the generative glands, the secreting surface of the thin lining mantle which forms the calcareous matter of the external shells. A tough outer dark epidermic layer is secreted from the surface of the peduncle of anatifæ, and the whole surface of the mantle pours out a mucous secretion.

In the annelides, besides the liver, in the form of biliary follicles, and the salivary and generative glands, we observe many of them to secrete a copious mucus, and often a colouring matter, which they throw out upon the surface of their body, as the yellow secretion, of an acrid nature, from the skin of the *arenicola*. The surface of their naked body is lubricated often by a thick, viscid, mucous secretion of considerable abundance, thrown out from distinct orifices of their surface. We perceive numerous distinct round muciparous follicles or glands, which pour out a copious secretion generally near the orifice of the organs of generation, as in the common earthworm. We have seen that many annelides secrete calcareous or other matters to form tubes for protection. Many of those red-blooded worms exhibit a very brilliant luminous appearance, extending along their body towards its centre when they are irritated. This we perceive in many of the minute marine annelides; but the true nature of the luminosity here, as in many other classes of animals, is unknown; it is suddenly excited, and suddenly extinguished, and appears to be subjected to the will of the animals. I have examined alive some of the minute luminous nereides, and excited them in the dark, and in sea-water, while under the microscope, and have seen the flashes of bluish-white light which they produce, extend along their alimentary canal, as if covering instantaneously the whole of the straight and wide alimentary canal, from the head to the posterior part of the body, with a vivid and fluctuating light, which is kept up for a longer or shorter time, and with more or less intensity, according to the irritation to which the worm has been subjected.

Besides the liver, consisting of two tubes and two salivary vessels, in the myriapods, and the testes and the ovaries placed on different individuals, we observe in the chilognatha, follicles opening by minute orifices along the sides near the haunches of the legs, which secrete an acid and strongly odorous fluid. In the chilopoda there are poison glands placed near the unciform palpi; many emit a shining phosphorescent light, and they have several glandular follicles connected both with the ovaries and the testes. The *iulus* has distinct urinary long vessels, which enter the lower part of their alimentary canal, at the beginning of the wide intestine. In insects we observe many of the secreting glandular organs already advanced to a considerable degree of development by their bulk, but not by their form. The complicated and lengthened tubular form of the liver we have already examined, and the more simple form of the pancreas and salivary glands in several of those animals. We observe, besides these important chylopoietic viscera, numerous other distinct glands, and those are also generally, whatever be their secretion, simple tubular lengthened organs, sometimes convoluted, which pour their secretions into the interior or upon the surface of the body. The testes and the ovaries are here remarkable for their subdivisions and outward complexness of structure. But besides those biliary vessels, there is often found an inferior pair of vessels, opening likewise into the intestine, and which have been found to secrete a suburate of potass and ammonia, from which they have been considered as urinary organs, or kidneys.

We often observe a distinct series of gastric glands, like minute follicles, opening into the stomachs of insects. Many coleopterous insects, especially the carnivorous species, present glandular vessels, which pour a very acrid matter into the rectum, and in the hymenoptera there is a poison gland developed in the last segment in many species, which transmits its secretion through a perforated duct of great density and sharpness, the sting of these insects. We observe in the course of the oviduct, that there is also generally a glandular organ of a kidney

form, which appears to secrete a fluid to envelop the ovæ, as they pass through the united oviducts. Many of these animals already distinctly present a rudimentary state of the kidneys, consisting of a lengthened, convoluted, undivided, glandular tube, shut at its distal extremity, and opening into the cloacal part of the intestine. We find even in some of the species, towards the lower termination of this urinary tube, that there is a dilatation—a cæcal recess, forming a distinct urinary bladder. We observe the larvæ of many of those animals, forming a secretion which (after being thrown out at first in a liquid state, from two glands in the silk-worm which open below the mouth, and in form of slender filaments) becomes condensed and hardened by exposure to the air, and gives rise to those filamentous substances in various forms, so important in the living economy of many species of articulated animals, to assist in their progressive motion, to suspend their ova, to entangle their prey, or to envelop and protect their own body while in the chrysalis state. Many of those animals when excited, or when on the wing, spontaneously produce brilliant flashes of light. Many of them which fly about in the evening, in the twilight, are gifted, especially in the tropical climates, with the means of producing this brilliant phosphoric light. Many insects emit from cutaneous follicles secretions possessing every variety of odour, as a means of protection when irritated, and often the odorous glands contained within the body near the anus, can be protruded from the body and retracted at pleasure. Some have the odorous follicles near the head, on the back, or along the joints of the trunk and legs. There are glandular follicles on the lower part of the abdomen of the bees, for the secretion of the wax in which they envelop their ova, and their honey is elaborated in the digestive organs, from the juices they have collected from the flowers of plants.

Distinct salivary, hepatic, and urinary vessels have been shown in the arachnida, and we observe, besides the chylopoietic glands and those connected with generation, that there are very often developed large distinct poison glands, accompanied by instruments to inflict wounds. Those poison-glands are sometimes situated at the anterior and sometimes at the posterior extremity of the body. The last segment of the body of the scorpion, as of many insects, is formed into a sharp curved sting, solid at the point, grooved at the sides, and leading by two minute lateral canals, continued from these grooves, to two poison glands situate above the broad base of the sting. It is not retractile like the sting of insects. In the tarantulæ and the spiders, as in the scolopendræ, the poison glands are situate at the sides of the mouth, and pour their secretions through the perforated, sharp, curved maxillæ. There are four subdivided glandular follicles in the lower and back part of the abdomen of the spiders, which open by four papillæ in front of the anus, and which secrete the glutinous threads that compose the webs. These glands can be suddenly compressed, so as to throw out the threads to some distance when required.

In the crustaceous animals we have seen the great magnitude, the lobed form, and the almost conglomerate structure, of the liver. The salivary glands, from their liquid element and moist food, appear to be seldom developed here even in the highest of the decapods, and the pancreas is ascribed to some of the entomostracous crustacea. The genital glandular organs, the ovaria, and the testicles, are double and symmetrical, as in most of the entomoid articulated animals. Most of the glands we have seen so numerously developed in insects are incompatible with the aquatic life of the crustacea, which have fewer secreting organs than any other entomoid class. The glands of the air-breathing entomoid classes are considered by Straus and others to be more simple and isolated in their form, on account of the limited development of their circulating system, as in myriapods, insects, and arachnida, and they possess a more conglomerate form in the annelides and the crustacea, where the sanguiferous system is more extensively distributed, because the blood in them can be more easily sent to all their minute subdivisions. The analogies of the chylopoietic and intestinal glands are determined, under their simple forms in these classes, chiefly by the parts of the alimentary canal into which they open, the salivary glands opening into the mouth or œsophagus, the hepatic, gastric, and pancreatic, opening into or near the stomach, and the urinary vessels near to the cloacal part of the intestine.

In the molluscous classes we have seen the great development and the lengthened subdivided and convoluted form of the alimentary canal, and the magnitude of the principal chylopoietic glands, but their liquid element and their slow movements little require the development of those numerous glands connected with the organs of relation which we find in the active articulated inhabitants of the land or of the air. We find no glandular organs developed in the tunicated animals besides the most common chylopoietic and

generative glands, the liver and ovaria but many of these animals secrete upon their surface a glutinous substance, which serves to attach particles of gravel or shells to the parietes of their tunic, by which they are protected and concealed, and we observe a luminous secretion produced by the *pyrosoma*, *salpa*, and other genera, as by many inferior classes. Even in the conchifera the salivary glands scarcely make their appearance, excepting in the *lingula*, among the brachiopodous genera. We observe the thick glandular appearance of the striated oral appendices, the copious secretion of calcareous matter from the outer surface of the mantle, and the mucous secretion of its interior, in most of the bivalvia, and, in the more delicate shelled genera, a glandular sac at the base of the foot, for the production of the filaments of the byssus. Their pearly secretions are spherical concentric layers of nacreous matter, secreted around foreign particles by the outer surface of the mantle. In the naked and in the testaceous gasteropods there are numerous mucous follicles disposed on the surface of the body to lubricate and protect the skin; and in the pectinibranchiate tribes, we commonly see distinct muciparous glands to moisten the interior of the respiratory sac. Many of these animals present also at the bottom of this sac, or near its margin, soft follicular glands destined to afford secretions of various and often lively colours, as the blue of the *janthina*, the yellow of the bullæ, the purple of the *murices*. The *janthina* derives the materials of this deep blue secretion by feeding on the *velellæ*, which float like it upon the surface of the sea. CHIAJE has shown the purple secretion of the *murex tritonis* to be produced by the parietes of a glandular sac situate at the bottom of the respiratory cavity, and communicating with that cavity by a small foramen. The float of the janthina is a secretion of a glutinous matter enclosing globules of air, and formed also by the mantle. In the pteropods as in the gasteropods the secreting organs are still almost confined to the most common glands connected with nutrition and generation. JACOBSON and TREVIRANUS have found uric acid in the supposed calcifiant gland of some gasteropods and conchifera. Glands apparently analogous to urinary organs are seen in many of the gasteropods, as the *umbrella*, *pleurobranchus*, *aplysia*, *doris*, and several other gasteropods.

In the doris this gland opens close to the anus, by a distinct orifice on the surface of the body. The secretion formed by the ink gland of the naked cephalopods, and so important as a means of protection to these defenceless animals, has been considered as analogous to the urinary excretion of the vertebrata. This gland has a cellular internal structure, thick vascular parietes, and a wide duct, which opens into the anal portion of the intestine. It is wanting in the nautilus, where the shell affords sufficient protection to the animal. The surface of the skin is covered, in the naked cephalopods, with coloured spots, resembling minute vesicles of the matter of the ink gland, slightly diluted. These spots, situate beneath the epidermis, are constantly enlarging or diminishing their diameter, and thus produce the undulating changes of colour we observe taking place on the skin of these animals. The great venous trunks, leading to the divided auricle, are covered, in these animals, with cellular follicles, which some have compared to urinary organs, others to a portal circulation. The ink of these animals is analogous to many coloured secretions of gasteropods. All the glandular organs connected with digestion and with generation are here presented in the most complex and conglomerate forms met with in the invertebrated classes.

In the class of fishes the spleen first makes its appearance—a gland apparently connected with the lymphatic system. The spleen exists here, for the most part, as a single small vascular organ, appended to the left side of the stomach; but in many fishes it exists in a subdivided form, as we see in the sturgeon. That subdivided form of the spleen we perceive also among the cetacea, as in the porpoise. The exterior surface of fishes is lubricated by a copious viscid mucous secretion, poured out on different parts of the body, from long, ramified, muciparous, subcutaneous glands. These are especially obvious and numerous on the head and sides of cartilaginous fishes. In many of the osseous fishes they are seen extending as a continuous tube along each side of the body, to the end of the nose, and sending down branches along the operculum and the lower jaw. These muciparous vessels open from distance to distance along their course; and they are often seen following the course of the lateral line on both sides of the body. The gaseous contents of their air-bag are generally secreted by highly vascular glandular parts of their parietes, which are obvious, generally, from their vascularity and their glandular thickened appearance on opening the cavity of the air-sac. This rudiment of the pulmonary organ of higher animals we have seen, however, to open, and to communicate more and more freely with the external atmosphere, in more advanced conditions

of its development in this class. Many osseous and cartilaginous fishes possess complicated electrical organs by which they are able to communicate violent shocks to animals which touch or approach them. In the *gymnotus* they occupy the inferior part of the whole caudal region of the body, and are divided by numerous closely approximated transverse membranous folds, like the plates of a galvanic pile, with a mucous secretion interposed between the layers, and largely supplied with nerves, as we find all the electrical organs of fishes. The two electrical organs on each side are separated from each other both by firm tendinous membranes, and by muscles, and extend tapering to the end of the tail. The transverse compartments are further divided by crossing membranes, which convert them into cells, the parietes of which are largely supplied with bloodvessels. In the *torpedo* these organs are placed on each side of the head, and are supplied with large nerves from the fifth and from the eighth pairs. These organs are possessed by many fishes, both of fresh water and of the sea. From Dr. Davy's observations on the torpedo, it appears that the frequent excitement of this organ rapidly exhausts the influence of the ganglionic nerves of digestion and secretion, and arrests those processes. The spleen appears to be deficient in the lowest of the cartilaginous fishes; it has not been detected in the lampreys, and appears to be wanting also in the myxene and the gastrobranchus.

The muciparous glands, so largely developed and extensively ramified on the body of the cartilaginous and osseous fishes immediately beneath the skin, we find in a more divided form, pouring out their secretion on all parts of the surface, in the naked amphibia. Their orifices are large and conspicuous on the back of the land salamander. These animals are almost as deficient in salivary glands as fishes and cetaceous animals; but the spleen constantly presents itself as a single lengthened organ on the left side and beneath the stomach. The thymus gland appears not to be developed in either of these two aquatic classes of vertebrata, the fishes and the amphibia; and it is remarkable for its deciduous character in the higher classes, where it appears as a normal part of the fœtus. The cutaneous secretion from the glandular follicles of the back of the toad is of an acrid and poisonous quality, and of an oily consistence, and very bitter taste; the glands are chiefly disposed on the back part of the neck, and their secretion is a means of defence. The spleen is still small and variable in its form, and in its position, in the reptiles, and appears to be wanting in some of the serpents. The poison gland of the serpents occupies the situation of the parotid gland, below and behind the eye on each side, and consists of numerous lobules, each composed of many minute convoluted follicles, all of which lead to a common duct on each side of the upper jaw. Each of these ducts passes forward to the base of the perforated poison-fang, where it forms a wide reservoir for the secretion, and is surrounded with muscular fibres, to compress the duct when required, and force the poison into the tooth. The cutaneous follicles of the gecko of India secrete a fluid which is said to have the same acrid and poisonous properties as that of the toad. Some reptiles, as rattle-snakes and alligators, possess anal glands, like many carnivorous quadrupeds, which secrete a strongly odorous substance, having the odour of musk, and the same structure appears to belong to some chelonian reptiles and to many serpents, both poisonous and innoxious. Besides these anal musk-glands, most of the crocodilian reptiles are known to possess two glandular follicles under the lower jaw, which secrete and pour out upon the surface of the skin a thick fluid with a similar odour. In some lizards, these odorous glands open on each side of the anus externally, and in most of this order of reptiles, we observe numerous inguinal pores for the discharge of a similar strongly-odorous secretion at the breeding season. The thymus gland, which first makes its appearance in reptiles, is there a permanent organ, as it is also in some of the lower mammalia, the cetacea, and the rodentia. It is, however, a transitory organ in birds, as in most mammalia, where it makes its appearance late in the progress of development, as it appears late in ascending through the animal kingdom. The spleen is sometimes divided in birds, as we find it also in some fishes and cetacea. In most birds we observe a short glandular cæcum opening into the middle of the posterior surface of the cloaca between and behind the openings of the two ureters. This gland opening into the cloaca is considered as the analogue of Cowper's glands in mammalia. It was considered by Fabricius to be a receptacle for the male fluid, and is denominated the bursa of Fabricius. It is sometimes divided so as to form the rudiments of two separate glands, as we find Cowper's glands in quadrupeds. Most of the feathered tribe, and especially the aquatic birds, exhibit on the back part of their body, over the region of the coccygeal vertebræ, two small glands, with their

ducts opening by tubular capillar, which secrete an oily fluid, and this oily fluid is employed by the aquatic birds to dress the surface of the feathers, and render the plumage impermeable to the water in which they reside. All the ordinary secretions of birds, from their high temperature and their great muscular activity, are formed, expended, and reproduced with great rapidity,—the mucous secretions of their buccal, nasal, and intestinal cavities, the serous transudations into shut cavities, as the abdomen and the pericardium, and especially the oily synovial secretions into the capsules of their ever-moving joints. The fluids of the eye, the ear, the lachrymal, the Harderian, and the nasal glands, the œsophageal and gastric glands, and the secretions of the oviducts, are all rapidly produced in this most hot-blooded and most active of all the vertebrated classes. This appears to depend, not on the highly-developed or complicated structure of the glands themselves, which are comparatively simple, but on the rapid transmission of highly arterialized and heated blood through their texture, and the high development of the nervous system on which the secretions so immediately depend.

In the aquatic mammalia, especially in the cetaceous animals, most of the secreting organs still preserve a very simple internal structure, even in those first-developed, most important, and largest glands appropriated to the assimilation of the food; but it is in the higher terrestrial orders in this class that we find all the more important glands arrived at their most complicated and most conglomerate forms, and numerous glands of a simpler structure appropriated to special purposes, connected with their various living habits. In the dolphins and narwhals the salivary glands appear to be altogether wanting, and the spleen in most of these animals is divided into several detached, small, round portions, connected only by sanguiferous and lymphatic vessels. The spleen is single and large in the ruminantia, of a lengthened equal form, and attached along the side of the paunch. Between the hoofs of most of the ruminating quadrupeds there is a tubular and slightly ramified glandular cavity, which pours out an oily secretion of a strong odour, to lubricate and protect the hard hoofs, and by which the carnivorous quadrupeds can trace the footsteps of their prey, and some of these animals have also odorous inguinal glands opening near the mammæ. The musk so extensively used as an aromatic is obtained from two glandular secreting sacs opening near the prepuce of the musk-deer. The spur of the ornithorhyncus was shown by Meckel and Rudolphi, to transmit through its tubular canal the poisonous secretion of a large gland placed in each thigh. In rodent quadrupeds there are numerous glandular follicles, situate near the anus or near the prepuce, which secrete strongly odorous, sebaceous, or oily fluids. Two plicated glandular sacs are found on each side of the genitals of the male and female beaver, which pour out near the organ of excitement the well-known fatty and resinous secretion, the castoreum of medicine. We have seen the lobed gastric gland of this animal, embracing the cardiac orifice of the stomach; and also in the wombat the same structure is presented, which assists in the digestion of their coarse food, and shows an analogy with the ventriculus succenturiatus of birds. In many of the rodentia the shut extremity of the long cæcum-coli is covered with small glandular cryptæ, which open into its cavity, and similar rudimentary glands occur in various parts of their alimentary canal. Anal glands secreting odorous substances are also met with in several of the marsupialia and pachyderma, but they are most developed in the carnivorous quadrupeds, where their secretion is remarkable for the intensity of its odour in the civets, badgers, hyænas, and some other genera. In the elephant similar glands are observed in the region of the temples, opening on each side by a single small round orifice, between the eye and the ear. But notwithstanding the infinite diversity of form, structure, and position, which we observe in these secreting tubular membranes forming glands throughout the animal kingdom, and the various modes in which we perceive the bloodvessels and the nervous filaments distributed on their surface, we cannot at present discover how far these are connected with the peculiar properties of the secretions they produce. Each of these complicated conglomerate forms of glands may almost be viewed as a new vascular system, like the chyliferous and the lymphatic, conveying fluids always in one direction, but that direction is from, and never to, the mass of the blood, being thus contrary to these two systems. Most of the products of these organs may, therefore, be considered as excretions from the blood, but destined to serve some useful purpose before they are discharged from the system.

On the Lymphatic System.

In the lowest tribes of animals all the assimilative functions are performed by the same simple digestive sac, but as we

ascend in the scale the functions become more complicated in their result, and special organs are appropriated to each portion of the complex process of nutrition. When the vascular system is first developed in the radiated classes, the arteries are scarcely distinguishable from the veins in structure or in function, and to this simple plexus of ramified tubes, in which the blood can often take a retrograde course, are confided the functions of chylification, sanguification, circulation, and even absorption. And, indeed, throughout the invertebrated classes the absorption of the nutritious matter from the intestine, and the absorption of the decayed materials from all parts of the body, appear still to be functions confided to the ordinary sanguiferous vessels. In the highest division of the animal kingdom, however, we have already seen a distinct system of vessels and glands appropriated to the absorption of the nutritious part of the food, and to its conversion into chyle, or almost into blood—the chyliferous system. Keeping pace with the chylific system in the march of its development, we find a distinct vascular apparatus, with accompanying glands, in the vertebrated classes, destined to take up from every point of the body the decayed materials, and to convey them to the circulating fluid, to be discharged by the excretions from the system. By this means the parts are enabled to grow, and to increase in all their proportions, and the vascular apparatus appropriated to this function of general absorption is termed the lymphatic system, from the limpid fluid these vessels convey. They have nearly the same relation to the venous system as the lacteals, and enter it at the same place, through the medium of the thoracic ducts, which are common to both systems. They are more extensively distributed than the lacteal vessels; they appear with them first in the class of fishes, and their glands appear to be earlier developed than the mesenteric. The limpid contents of these vessels are sometimes slightly yellowish, reddish, or whitish in their colour, and are coagulable, and abundant in globules, like chyle, blood, or milk. The vessels conveying this fluid occur abundantly in all the vertebrated classes, and are distributed over every organ, following the course chiefly of the large and deep-seated arteries and veins, and occurring over all the subcutaneous parts, so that they appear to confer the property of rapid absorption on all the mucous and serous membranes, and on all the other tissues of the body, by their quickly conveying the transuded matters to the circulating blood.

The lymphatic system, though extensively distributed over the body in the class of fishes, as has been long known, still presents a very simple condition in its essential parts. Not only are the glands still undeveloped on these vessels, but the valves scarcely yet make their appearance, excepting at the openings of the lymphatics into the veins, and the parietes of the vessels appear as a simple, thin, and soft tunic. They have been seen in almost every form of osseous and cartilaginous fishes, excepting in the lowest cyclostome species, as the myxine and the lampreys. Their functions, like those of the lacteals, appear to be performed in the invertebrated classes by the veins, or they have not been detected in them, from the limpid colour of the sanguiferous fluid itself in these inferior classes. Instead of the conglobate glands, which are seen on the lymphatics in higher classes, we observe in the fishes only groups of convoluted, or tortuous and anastomosing vessels, which thus present us with a kind of analysis of these higher forms of lymphatic glands. The few glands seen on the lymphatics in the neck of the roach are regarded by Meckel as the rudiment of the thymus, which he considers, as well as the spleen, as merely a lymphatic gland.

Monro considered the subcutaneous muciparous vessels of fishes as lymphatics which opened by large orifices on the surface of the body, but he observed that the ordinary lymphatic glands were still wanting in this class. Now you will observe, from these numerous plates of Fohmann, representing his injected preparations of the lymphatics of various fishes, how very extensively these vessels are spread, both over the superficial and the deep-seated parts of their body. From the thinness and softness of their coats, these lymphatics appear generally very wide and sacculated, and they present numerous constrictions of their parietes, as if from the development of rudimentary valves. They already cover, by their numerous plexuses, the whole surface of the larger veins, especially when they are distended with injected matter; as we see also beautifully represented in these large plates of Panizza, representing the injected lymphatics and lacteals of various reptiles. The direct communications of many of these lymphatics with the branches of veins pointed out by Fohmann, are ascribed entirely, by Panizza, to rupture of the vessels and transudation, not only in fishes but in all other classes. The large sacs and receptacles which are commonly seen on the injected lymphatics of fishes, are, for the most part, produced by the pressure of the injected matter on the thin and distensible sides of these vessels. We commonly

observe two great lateral plexuses of lymphatics passing forwards on the trunk of fishes, to terminate with the anterior ventral plexus, in the thoracic duct behind the heart. Those of the head and dorsal parts enter it anterior to this point.

The lymphatic vessels have been shown, by the numerous careful injections of Panizza, to be no less extensively distributed through every part of the body in the *amphibia*, or the naked batrachian animals; and they appear to him to be here, and in all the higher classes, a distinct system of vessels, from their origin to their termination by great trunks in the venous system. He considers these animals as incapable of respiring through their soft and naked skin; and he regards the skin as altogether different in its nature from mucous membranes. In these large folio plates he has represented their distribution over the body and the interior viscera of frogs and salamanders, as well as in serpents, lizards, crocodiles, and tortoises. He discovered at Pavia, at the same time with Muller at Berlin, two pairs of pulsating cavities on the lymphatics of the trunk in these animals; and he has pointed out similar pulsating sacs on the lymphatics in reptiles and in birds. The pulsations of these sacs are not synchronous with those of the heart, nor even with each other; and they continue after the heart has been dissected from the body. In the frog they are seen pulsating through the skin, without dissection, the anterior pair situate above the broad transverse processes of the third cervical vertebra, and the posterior pair on each side of the free end of the long coccygeal bone, near to the sides of the anus. They propel the lymph into the neighbouring veins.

These splendid folio plates of Bojanus and of Panizza show the great extent and the plan of the distribution of the lymphatics in the chelonian reptiles. Panizza has not been able, by all his injections, to discover a single direct entrance of a lymphatic vessel, or of a lacteal into a vein, even in the lymphatic and mesenteric glands, and he ascribes the communications pointed out by other observers, to the rupture of vessels, and the extravasation of the injected matters, especially in the glands, where the minute lymphatic capillaries twine round and interlace with the veins. These glands are not yet developed in the reptiles, and their place is supplied by the tortuous windings and subdivisions of the vessels themselves, as in the lower cold-blooded vertebrata. The injected preparations of these vessels in the chelonia show almost every organ of their body to be covered over with a compact layer of the lymphatics or absorbents. They are always wide vessels, and they present a knotted or beaded appearance, from the constrictions caused internally by the valves, and the dilatations of the vessels between these valves. Panizza has detected a pulsating sac on the lymphatics of the posterior part of the trunk in the *coluber flavescens*, like those seen in several amphibia. The lymphatics are remarkably abundant on the spleen in the chelonian reptiles, and in the amphibia; and Tiedemann imagined that all the lacteals of the mesentery in these cold-blooded classes passed through the spleen before entering the thoracic ducts. We have already seen that the lacteals and the thoracic duct are very largely developed in the vegetable-eating chelonian reptiles, and there are generally two or more ducts to convey the chyle and lymph from the wide receptaculum to the veins of the neck. The imperfect development of the valves still allows the injections to pass from the larger trunks towards the branches and capillaries of the lymphatics in all the reptiles. In the class of birds the valves are more developed, the lymphatic vessels are more numerous, and are more firm in their parietes, and less wide and sacculated than in the chelonia. They are here, as in other classes, seen clustered round the trunks of the great vessels of the extremities and of the trunk. Their course is now more direct, and glands have been observed on these vessels in the neck, though they are not yet developed on the lacteals of the mesentery. The lymphatics from the lower extremities and posterior parts of the trunk, enter a large plexus or receptacle at the origin of the cæliac artery, along with the lacteals from the lower portion of the intestine. The lymphatics from the head and anterior parts of the body enter the two great trunks of the thoracic ducts, to be poured with the chyle into the angle between the subclavian and jugular veins. As many as six lymphatic glands have been observed on each side of the neck, in some of the larger predaceous birds. It is in the class mammalia that we find all the parts of this absorbent or lymphatic system the most developed, and in the condition the most isolated from the sanguiferous and the lacteal systems. The lymphatics are here more numerous towards the superficial parts, and form almost a stratum, distinct from the deeper-seated plexuses which accompany the great bloodvessels of the extremities and of the trunk. Their outer and inner coats are more distinct, their valves are more numerous, more complete, and more effec-

tive in guiding the course of the contained lymph, and in preventing the flow of injected fluids against their natural direction. The glands are large and numerous in the course of these vessels, especially in the groin, in the axillæ, and on the sides of the neck. We have seen that their contents are conveyed, with the white opaque lacteal fluid, by means of a single thoracic duct, into the left subclavian vein. There is a separate small lymphatic duct on the right side of the neck. Now the direct communication of these lymphatic vessels, with veins in other parts of the body, observed by many anatomists, has been always observed by PANIZZA to result from rupture and extravasation. FOHMANN imagined that in the seal all the fluid poured from the small intestine into the pancreas Asellii was taken up only by veins, but it was shown, first by ROSENTHAL, and then by RUDOLPHI, that there are distinct lacteal vessels issuing from the group of glands which conveys the chyle to the thoracic duct, as in other animals. Notwithstanding the fibrous coat of the lymphatic vessels in the mammalia, and the distinct pulsations in the lymphatic sacs, seen in several of the lower vertebrated classes, no distinct contractions or pulsations have been detected on any part of the lymphatic system in the highest class of the animal kingdom.

LECTURE LIV.

ON THE EXCRETING AND TEGUMENTARY ORGANS.

THE decayed materials of animal structure taken up by the lymphatics from all points of the body, are conveyed by them to the circulating blood, to be removed from the system by distinct organs, or by the general excreting surfaces of the body. But animals without lymphatics, and even without bloodvessels, possess the means of separating from their economy the old materials which for a limited time have formed a part of their system; and where those separated materials do not appear subservient to some useful purpose in the maintenance of the individual or the species, they are regarded as excretions. There can be little doubt that such excretions are pouring incessantly, in a gaseous or in a fluid state, from the exterior cutaneous surface of the body, or from the internal mucous surface of the alimentary cavity, in all classes of animals, from the polygastrica to the mammalia, however inappreciable those products may be. The naked surface of animalcules is protected from the saline ingredients of their aquatic medium by a cutaneous exudation, as the naked surface of mollusca is by its copious mucous secretion. Flocculi are discharged from the canals of porifera, along with the currents, which appear to consist of particles of foreign matter, mixed with the natural excretion from the parietes of these ramified internal absorbent passages, and similar flocculi are observed periodically to detach themselves, as a thin mucous or epidermic excretion, from the fleshy surface of zoophytes, and of almost all the naked animals higher than them in the scale. The luminous, the electrical, and the stinging materials evolved by many of the inferior tribes are so little connected with nutrition or with generation, that they are nearly in the condition of excretions, as also are the numerous poisonous fluids and odorous materials formed by animals for self-defence, the gaseous materials evolved in respiration, whether by cilia, by branchiæ, or by lungs, and the fluids perspired by the skin. These excreted materials, like the secretions of animals, are but substances derived from the vital fluids, and modified by their transmission through membranes, follicles, or glands.

The most important and distinct emunctory organs, however, developed in animals, are the urinary apparatus, which exert the most immediate and the most extensive influence over the condition of the vital fluids, and which generally convey their heterogeneous and copious products into the cloacal or terminal part of the alimentary canal to be discharged directly from the system From the tubular, ramified, respiratory organs of the *holothuriæ*, opening into the cloacal part of the intestine, and from the constant currents of water which thus pass to and fro through the anal aperture, these organs may obviously perform the functions of the two great emunctories of higher animals, the respiratory and the urinary organs. In many insects and arachnida we observe, besides the ordinary biliary tubes, opening into the higher chylifiant portion of the alimentary cavity, distinct small secreting tubes or follicles, which convey their products into the terminal or lower excretory part of the intestine, and which appear, therefore, to present a rudimentary condition of the kidneys. These often open near the anus, and they have been found by several chemists to contain in their secretion distinct indications of uric acid, in the class of insects. They are described by TREVIRANUS in the *iulus* among the myriapods. Similar urinary or renal follicles are met with in some of the crustaceous animals. In the coleopterous insects there is often a minute

vesicle, like a urinary bladder, into which one or two renal tubes convey their secretions before it is poured into the wide rectal part of the intestine. In several of the terrestrial and fresh-water gasteropods, uric acid has been found in a distinct sac, thus serving the office of a kidney, and we frequently find in the molluscous classes, excretory sacs opening into the rectum or near the anus, or into the genital passages, such as the inky excretion of the naked cephalapods, the anal sac of the doris, and the coloured excretions of other genera. The urinary bladder is developed in the articulated classes as a mere dilatation of the duct or tube which constitutes the gland, as the gall-bladder is an enlargement or reservoir of the hepatic duct conveying the secretion of the liver.

No organs are more constant in the vertebrated classes than the two kidneys, and the urinary bladder is one of the most variable and inconstant. They are generally of a larger size and of a simpler structure in those animals which have a limited extent of respiration, so that their bulk is commonly in the direct ratio of that of the biliary organs. In the class of fishes the kidneys have a simple structure and a lengthened form, excluded from the cavity of the peritoneum, as in higher animals, by the peritoneal coat passing over their abdominal surface, and attaching them along the sides of the vertebral column. They consist of lobed organs that are closely approximated to each other on the median plane, like those in the highest classes of animals at the first commencement of their development. They consist of ramified ureters, the branches of which assume various forms, producing this lobed appearance, so constant in the class of fishes; and over those capillary ramifications of the uriniferous tubuli which compose the mass of the kidneys, the blood is distributed in a manner which differs in the different classes of animals, giving rise to the various textures we observe in the interior of their kidneys, as in other glandular organs. Sometimes those uriniferous vessels are disposed parallel to each other; sometimes they are more ramified, convoluted, and subdivided, forming that lobed appearance which we observe to be permanently retained in all the lower classes of vertebrated animals, and which is found in the first condition of the kidneys in the highest classes. The kidneys are larger in fishes than in any other class, perhaps from their aquatic medium, and the quantity of fluids constantly taken with their food.

In fishes, the urine which is formed in those capillary uriniferous tubes is poured directly into the two long and wide ureters, without forming a distinct enlargement or pelvis of the kidney, as it is termed, in higher animals. This ureter extending along the sides of all the separate small lobes in each kidney, receives the urine from each, and pours it thus through the remaining part of the canal, often directly into the cloacal termination of the intestine, without forming a urinary bladder. That terminatian of the ureters is situate in the most posterior part of the anal opening; it is posterior to the genital organs, and the genital organs in fishes, whether male or female, are themselves posterior to the rectum. Thus the position of those parts is the reverse of that which they have in the mammalia, where the rectum is behind, and the urinary openings are in front of the others, in the pelvis. Frequently, however, there is developed in fishes a comparatively small urinary bladder, which receives the terminations of the two ureters. This, to a small extent, allows of the accumulation of the urine, which is discharged by an opening, or a short urethral passage, at the back part of the general opening of the cloacal or terminal part of the intestine.

Now these long-lobed kidneys of the fishes extend often as far forwards as the cranium, behind the heart and gills, and backwards into a pelvic cavity behind the anus. They run so close to each other that they are often united together for a part of their course on the median plane, sometimes on their anterior portion and sometimes on their posterior; but this is not accompanied by any communication of the uriniferous tubes of the one kidney with those of the other. The anterior part of the kidneys is often much enlarged by the development of a lateral lobe on each, and we find them, again, greatly increased at their anterior end in the class of birds, where the lobed form is still distinctly preserved. The numerous arteries which supply these lobes come off directly from the trunk of the aorta, or from the intercostal arteries which come from its sides, and the renal veins mostly enter the vena cava as it passes forwards between the lobes of the kidneys. The kidneys are smaller and shorter in the cartilaginous fishes, like those of chelonian and most other reptiles, and the ureters enter with the vasa deferentia into a common short urethral passage. The kidneys, like other glands, consisting of ramified tubes which assume a conglomerate form, at first appear as simple tubes running along the back part of the abdomen, from the sides of which short and simple tubuli are developed, and these become at length so

subdivided, long, and tortuous, as to present in the adult state this uniform, soft, pulpy, and lobed mass.

In the amphibious animals, the kidneys have a less lobed and a less lengthened form than in the osseous fishes, and the urinary bladder is of great size. We observe it in the frogs, salamanders, and some others of those amphibious animals, to be partially divided by a bifurcation, at its upper part, into two portions, and the bladder is here constant, as in the chelonian reptiles, in its appearance. It receives the ureters, conveying the urine from the lobed and still lengthened kidneys, and which are contained high in the dorsal part of the abdomen,—the ordinary position of the kidneys, in all the inferior or oviparous classes of vertebrata in their adult state, and in the mammalia themselves at an early period of their existence. They begin in the amphibia, as in fishes, by being long slender tubes, extending along the sides of the vertebral column; and from these the little lateral tubuli bud out in the larva or tadpole state, as you observe represented in these magnified views of Muller. They are also more closely approximated to each other along the vertebral column, in the larva state, than in the adult condition of the frogs; and they retain a more lengthened form in the perennibranchiate amphibia, as we see also in fishes. Even in the tritons they have been observed to retain, to a comparatively late period of growth, their fœtal or primitive form, which is more quickly changed in the frogs and toads. It would appear, from the observations of Muller, that the shut extremities of the little short lateral tubuli are distinctly perceptible in the embryo, in the soft homogeneous cellular tissue of the kidneys, before the ureters themselves are yet developed; that the tubuli lengthen by the extension of their necks, and that these organs are thus developed, like most others, from the periphery towards the centre.

In the reptiles we observe a greater variety in the form and structure of the urinary organs, and especially in the presence or absence of the urinary bladder. In the serpents, as you observe by the kidneys before you of the boa constrictor, they have a remarkably regular, lengthened, subdivided, and lobed form, consisting of a long series of flat imbricated transverse lobes, that appear compressed between each other from before backwards. They are separate, like so many small kidneys pressed close to each other, each of which pours its secretion into the common ureter of the same side, without forming a distinct wide membranous pelvic enlargement, and without calices, such as we see developed in the more concentrated forms of the kidneys in the mammalia. They partake of the lengthened form so remarkable in almost all the organs of serpents. The left kidney is placed farther backwards than the right, while in the other reptiles they are both placed in the same transverse plane of the body. They are here more completely surrounded with peritoneum, and suspended freely, to allow of greater motion of the vertebral column with safety, where there is no sacrum. Each lobe is like a distinct kidney, and its numerous, small, tortuous, uriniferous tubuli, open by a common duct into the ureter, which follows, as usual, the inner margin of all the lobes; so that each lobe consists of a mass of very fine tortuous ramified tubes, arising from a common wide and short duct. The ureters open separately into the back part of the cloaca, as we commonly see in those fishes, saurian reptiles, and birds, which have no bladder developed. These minute tortuous tubuli preserve the same size and diameter throughout almost the whole substance of each lobe, and the same confused tortuous diverging course, so that there is not that distinction of cortical and medullary portion of the kidneys which we find so remarkable in a section of these organs in the mammalia.

In the saurian reptiles we commonly find the kidneys farther backwards in the pelvic region, and there is frequently a urinary bladder, but in the crocodiles and some others there is none; and in them, as in birds, we find that the two ureters terminate at a distance from each other in the back part of the general cloaca. And even where there is a urinary bladder in the saurian reptiles, the ureters do not terminate directly in its cavity as they do in most mammalia, but separately at its neck in the cloaca, as we see in amphibia and chelonia. These large bladders appear to contain the whole of the allantois which has not extended from the umbilicus, as it does in higher tribes of animals, where a great part or the whole of it becomes obliterated in the urachus. In the crocodiles the kidneys are more lobed and more complicated internally than in the lizards. They appear externally more like those of the serpents, but the uriniferous tubuli do not form tortuous groups arising from single ducts; they here diverge from a central wide duct in each lobe, and run parallel to each other to the periphery of the lobe, so that a section of a lobe appears, like a leaf, with parallel rays diverging to the margin

from a central vessel or duct. To compose these lobes the ureters divide into numerous trunks, which pass along the axis of the lobes, and subdivide, in a pinnate manner, into minute parallel tubuli, which extend to the circumference.

In the chelonian reptiles the urinary bladder is of greater size than in any other class, and accords with their limited cutaneous perspiration. The kidneys themselves have a more concentrated and a shorter form, and appear less distinctly subdivided into lobes than in the inferior vertebrata; they assume more the convoluted form, on the surface, which they present in the crocodiles, which indicate the limits of the tortuous lobes of which they are here composed. The tubuli uriniferi are more tortuous than in the crocodile. The cartilaginous fishes, as the rays and sharks, already present, outwardly, the concentrated and undivided form which we perceive in a greater degree in these chelonian reptiles. The ureters in the chelonia convey the urine into a very large urinary bladder; generally it is partially divided into two, and sometimes into three, lobes at its upper part. Like the respiratory allantois of the fœtus of higher classes, it is a great development from the cloacal part of the intestine, and although the ureters do not terminate directly in it, uric acid is found in its viscid contents, as in the large urinary bladder of the batrachian animals.

In the class of birds the kidneys are still constantly and deeply divided into numerous lobes of considerable size, which are lodged in the deep cavities that are seen along the sides of the interior of the sacrum. In each kidney the upper lobe is more detached, and is large, compared with the rest, and it receives a distinct renal artery from the aorta, each of the smaller lobes receiving twigs, as they descend, from the femoral artery, or from the large sacra media. The secretion collected from all those irregular large separate lobes is conveyed to the posterior and lateral part of the cloaca, into which the two ureters open, by two projecting papillæ, and thus the urine, containing a large proportion of urea, is directly mixed with all other excrementitious matter conveyed into the cloaca. The openings of the ureters here preserve the same situation as they have in the reptiles. But in the ostrich, which makes so near an approach to the class of quadrupeds, the ureters terminate at the lower margin of a greatly enlarged cloacal cavity, which allows the secretion to accumulate, and serves the purpose of a bladder, which indeed is itself only a development of the cloacal part of the intestine. Now the want of a urinary bladder in birds has been ascribed to the extent of obliteration of the allantois and urachus, which are continued from the cloaca. The struthious birds present not only the most distinct bladder, but also the most concentrated form of the kidneys, by the close approximation and union of all their lobes. The surface of the kidneys in birds, when minutely observed, presents a convoluted appearance, from the meandering distribution of the small lobules, formed by the shut ends of all the uriniferous tubes. These organs appear in the embryo as a soft, transparent, almost homogeneous, mass, in which the convoluted and foliated texture is gradually evolved, and the extremities of the uriniferous tubes which compose the lobules become perceptible; but these organs are preceded in their development by two other follicular glands, the ducts of which end likewise in the ureters—the *corpora Wolffiana* of Rathke. These corpora Wolffiana, composed simply of transversely-disposed tortuous follicles, are already large before the development of the kidneys, and afterwards gradually diminish in size; they are considered as more connected with the evolution of the genital than the urinary organs, in the classes where they are observed. The minute uriniferous tubes, directed in a pinnate manner to the surface of the lobules of the kidneys, produce perceptible interlobular spaces, which are occupied, as in other glands, with the capillary bloodvessels, and the minute sanguineous vesicles are seen on those vessels in the interior of the organ, as in the kidneys of mammalia.

In the class of mammiferous animals, we observe that the cetacea, and many of the inferior herbivorous tribes, exhibit a lower condition than most of the carnivora in the development and concentration of the kidneys; this is indicated by the lobed appearance which it preserves in them through life. This lobed condition of the organ is seen also in the comparatively slow-moving plantigrade carnivorous quadrupeds, as you observe in these kidneys of the bear and of the badger, belonging to that order. The same is found in the amphibious mammalia and many of the pachyderma, and in the otter. Each kidney consists only of four lobes in the elephant. The kidneys in those inferior animals retain their embryo condition, their subdivided form of lobes, through life,—that primitive form which you have seen permanently retained also in birds, reptiles, amphibia, and fishes.

But the higher animals belonging to this class, you observe the kidneys early to become more concentrated in their development, by the junction of all those lobes into a single compact organ, which almost always presents, internally, an appearance of a cortical and medullary portion, produced by the straight course of the minute uriniferous tubes in the central part, and their tortuous course in the exterior portion. This intimate structure is seen not only in each of the separate lobes of the kidney in the human fœtus, but in the component lobes also of the adult lobulated forms of the kidneys of inferior quadrupeds. The number of papillæ and of infundibula varies as much as the number of lobes; but the laws of the remarkable differences in the form of this organ are not yet distinctly perceived, nor are those which regulate the striking differences which present themselves in the extent of development of the cortical and medullary portion of the organ. The little transverse layers of glandular follicles composing the corpora Wolffiana, appear before those of the kidneys in quadrupeds, as in birds and reptiles. The kidneys appear at first as a congeries of tortuous follicles, radiating to the periphery, of a round gelatinous soft mass, and terminating around the exterior surface of the organs, in small pyriform sacs, like the vesicular terminations of the bronchial tubes in the lungs. These terminal vesicles diminish and disappear as the tubuli lengthen and become convoluted or tortuous and interwoven. The tubuli in the central part become more straight and parallel, and grouped into fasciculi, which compose the medullary part of the organ, while the tortuous interwoven peripheral parts of the tubuli form the cortical portion of the kidney. These groups of parallel tubuli meet at their open extremities and terminate in the papillæ, which are surrounded by calices, opening generally into a common wider receptacle, or pelvis, from which the ureter commences. The course and the termination of the ureters, and the general form of the urinary bladder, present few varieties of interest in this class, and for the most part they accord with the disposition of those parts in the human body. The urinary bladder, like the alimentary cavity, is more capacious in the herbivorous tribes of quadrupeds than in those which feed on animal substances. Thus we observe that there is great uniformity of plan, and a gradual development and increasing complexness, in the structure of these common emunctory organs, as in almost every other organic system, as we ascend in the scale of animals.

Of the Tegumentary Organs.

The body of animals being thus an aggregate of various complicated and delicate machinery, is more or less protected from the surrounding elements by some form of exterior integuments. In the higher animals, besides the dense scales, hairs, spines, feathers, and other parts which form the most exterior of the tegumentary organs, we find exuded from the highly vascular and delicate surface of the true skin, a thin layer of rete mucosum and an exterior epidermis, which are unorganized, like the shells of inferior tribes of animals. But although we find those tegumentary substances occurring so generally over the soft and delicate surface of the bodies of the highest animals, they do not alike exist over the whole of the superior tribes. In the lowest animals the simple cellular tissue of the body appears not to have yet excreted upon its surface any distinct and separate unorganized extra-vascular layer analogous to the epidermis. It appears as if the cellular tissue in immediate contact with the surrounding elements had merely assumed a more dense texture, or was more compact and more highly organized than in the interior of the body. A part analogous to a true skin is thus formed, which, like mucous surfaces, exudes a soft mucous secretion, but not the consistent varnish forming the ordinary scaly epidermis. This appears to be the case with the cutaneous covering of several of the inferior classes, as the polygastrica, the poriferous animals, the zoophytes, the acalepha, and even higher classes. We cannot trace a distinct skin or cuticle as a separate membranous layer on the delicate surface of the hydra, or on the naked polypi or fleshy parts of other zoophytes. In the acalepha, where the primary cellular tissue still composes so large a portion of the body, and where so few organs yet appear to exist in the interior of this tissue, even in a rudimentary state, we cannot separate from the surface a distinct epidermis, nor even a distinct membranous cutis. It appears that the cellular tissue composing the greater part of the body is there, as in inferior classes, merely more firmly and more densely organized in its texture, and more capable of resisting the influence of the external medium in which those animals reside. We might imagine, upon looking at the dense calcified covering of most of the echinoderma, that an enveloping crust was analogous to an epidermis or a rete mucosum; but upon examining the growth and nature of those shells, and their surface in the living state, we perceive that they are rather enclosed beneath

the surface of the fleshy substance, being covered with a living organized delicate integument, which secretes in layers the calcareous matter which we have already considered as forming their skeleton. The spines themselves are covered externally with this delicate living membrane that secretes internally the calcareous matter, and externally a soft mucous fluid, as in animals which have no shelly coverings to protect their interior, or to support their organs of motion.

It is in the articulated classes of animals that we find the distinct development of a completely external epidermic covering which appears to be entirely extra-vascular, exterior to the surface of the true skin, and enveloping in its substance the calcareous matter of the shell, when that glutinous varnish is strengthened by that secretion. We do not perceive this on the surface of the softest helminthoid animals, but many of them exude it in large quantity, to mix with the earthy particles of their solid covering, as we see in those which inhabit tubes.

In the myriapods this superficial dense cutaneous exudation has assumed such a form that the animal cannot protrude the soft parts of its body from the solid tubes that are thus formed. Those dense calcified parts are covered with a thin film, which is the first layer exuded from the surface of the true skin; beneath that is the colouring matter, and beneath this again is the denser chitine, generally, in the articulated classes of animals, consolidated by the phosphate of lime. The epidermis in those articulated animals is distinctly developed; and we may regard the whole of the superficial thin film we find covering the colouring matter in the crustaceous animals, and in the other articulated classes with articulated members, as analogous to the epidermis. The colouring matter itself is beneath this first exuded unorganized film, and beneath that colouring matter again is the calcareous matter. These are in contact, during the greater part of life, with the true skin of the animals into which the muscular fibres are inserted. Thus you perceive, that what we have already seen to be the skeleton of those animals occupies a part of the body beneath the epidermis, and analogous to the position of the rete mucosum in man—the chief seat of colour in the animal kingdom.

In the molluscous classes of animals we observe that there is generally perceptible a thin epidermic layer, like a varnish, that covers the exterior surface, not only of the calcareous matter of the shell, but of the colouring substance disposed upon the surface of the calcareous deposit. You are not to regard this, however, as the only proper epidermis of the animal's body. There is a thin epidermic covering over the surface of the true skin of the animal, contained in the interior of the shells, and what we look upon as the covering of the dense shell is an exudation, perfectly unorganized, which is deposited by the exterior secreting mucous surface of the mantle itself. This exterior glutinous epidermic exudation you can distinctly perceive is also formed by successive deposits, like the shell; it is not a substance here, nor in the vertebrated animals, which is growing by its own vital properties, and spreading continually over the surface of the shell, and keeping pace with the increasing growth of the shell. This exterior varnish has no means within itself, in any class of animals, high or low, of such growth and extension. In some cases it is continuous with the edges of the successive layers of the shell itself; in others it appears to be an exudation, first deposited by the surface of the mantle, and extended for some length; afterwards the colouring, mixed with the calcareous matters, are deposited beneath its surface. In this case, and in successive layers, the epidermis thus grows with the shell, and precisely in the same manner. This, therefore, you perceive, is a substance less capable of increasing in its dimensions than that epidermic covering which immediately envelops the delicate soft skin of those molluscous animals. When the epidermis, from its exceeding thinness and softness, is thus capable of being expanded along with the growth of the body, and of being constantly preserved in contact with the surface of the true skin, the dried and hard coverings in contact with the skin of the entomoid classes are not capable of thus expanding with the growth of the soft parts, and are, therefore, periodically cast and renewed. The copious mucous secretion from the skin of molluscous animals preserves their epidermis soft, and capable of expansion and of growth, by addition of new matter, where it is not hardened by calcareous particles.

Covering the surface of the body in the naked cephalopods, we observe a very thin, transparent, colourless, and soft epidermis. Beneath the surface of this epidermis, and exterior to the true skin, consequently in the situation of the rete mucosum, are situate the remarkable coloured spots, so constantly varying their diameter, which appear to be a coloured fluid, confined to small depressed flat vesicles, capable of greatly enlarging and contracting, even on parts of the skin removed from the body, and, by their opacity, and their variable di-

mensions producing the clouded colouring which we see, as a means of concealment, in the living state, constantly and rapidly passing and repassing over the surface of their body, especially when they are touched or irritated in any way on the sensible surface of their skin. Thus, in the invertebrated tribes, not only is the highly organized vascular and sensible skin distinctly formed, and its coagulable exudation the epidermis; but we observe between these an extraordinary development of the pigmentum accompanying the calcareous exudation of the skeleton. This pigment in the invertebrated animals is generally most developed, and most varied in its hues, on the side of the body most exposed to the light, as on the upper side of the wings of insects, and of bivalved shells that are fixed at the bottom of the water; and we see the same law in most of the coloured superficial parts of vertebrata. We see horny or albuminous exudations, formed in large quantity in the poriferous and polypiferous classes, and these assuming the forms of hairs, and setæ, and cirrhii, in the helminthoid classes, as in the transverse bands of shining hairs in the *halithea*, the tufts of setæ in the annelides, and the downy surface of larvæ, of crustacea, and of other articulata, which grow from their base like the hairs of mammalia. We see this filamentous form assumed by the epidermic covering of many conchifera, and in the byssus secreted by the same animals. Before these tegumentary parts become distinct layers or organs, we find the cuticle, the vascular and sensitive corium, and even the subcutaneous muscular fibres, blended together, to form an irritable, sensitive, and often coriaceous, contractile, general integument, which possesses all their properties.

In the vertebrated classes, the tegumentary organs are closely related in their forms to the ordinary temperature of the body, and the density of the element in which the animals reside. The warm-blooded classes are covered with slow conductors of caloric, in order to preserve the high temperature of their blood; but the cold-blooded classes are indifferent to the conducting power of their exterior covering. In the fishes, there is a thick, soft, gelatinous, and sensitive skin, intimately attached to their muscular system, and which is especially strong where the superficial scales are small or wanting. The cuticle is, nearly, as in the soft naked molluscous species, like a thin mucous layer; and, by its periodical shedding, the lively colours of the rete mucosum, are allowed to shine with more intensity through the pellucid scales, and this is most brilliant at their season of love. The imbricated scales which cover their surface, are strengthened, like the bones, with phosphate of lime, and grow by successive layers, added by the corium in which they are fixed.

From the necessity for free respiration by the surface of the body in the amphibia, the surface is destitute of scales, the corium is highly sensitive and vascular, and the epidermis is very thin. The cuticle is exuviable, and cast apparently with great rapidity and frequency. It appears to be thrown off in the frog almost every month, when the animal is watched in a state of confinement.

The delicate true skin possesses a tough fibrous elastic texture and a high degree of sensibility, and it is provided with numerous minute pores, from which a copious secretion is thrown out, to lubricate and protect the surface of the animal. The bloodvessels are extensively thrown over the superficial portion of this remarkably loose and free integument, and effect a respiration of the circulating fluids, which, during hibernation, is often the only respiratory organ which is in action. This cutaneous respiration has lately been denied by PANIZZA.

There is a beautiful disposition of colours over the surface of those epidermic developments, in the class of reptiles, connected with their living habits, and which is perceived only when we know their living history. The transparent mottled hues we see in those large flat sessile epidermic scales in the turtles, correspond with the dark and varied colours presented by the marine plants upon which those animals rest and feed at the bottom of the sea; so that it is a means of concealing and protecting those animals. Other chelonia, again, inhabiting the land, are of a dark and almost black hue; these are found concealed among the growing shrubs, and resemble the surface of the ground upon which they reside, or in which they burrow.

The rough tuberculated surface of many of the saurian reptiles, such as the alligators, the crocodiles, and the gavials, composed of large ossified sessile plates, resembles the decayed bark of trees in its colour, and even its longitudinally grooved and carinated form, so that it is a means of protecting those animals, and a means of concealment, by which they are the better enabled to secure and overtake their prey. The beautiful colours of serpents, and of the lizard tribes, correspond often with the colours of the trees, the branches, the flowers, or the leaves, among which they are most frequently found, and among which they obtain their prey.

In the class of birds, the corium is thin, vascular, and connected slightly with the subjacent muscles; the rete mucosum is colourless, and the epidermis thin, dry, and scaly, from the high temperature of the surface; the scales and hairs of other classes are here in form of feathers, which vary remarkably in their exterior appearance, their colours, forms, magnitude, and every other character. In the arctic birds we see a great development of that soft, compact, and downy form of the plumage, which in most of the southern birds is but imperfectly developed, and is here beneath the larger feathers, and next to the surface of the skin. These form a compact dense covering next the surface of the body, which is one of the slowest conductors of caloric, and keeps in the great heat in the interior, preventing the abstraction of the internal heat by the coldness of the exterior medium. The feathers of birds are but hairs developed to that form in consequence of the high temperature and vascularity of the surface, and the extent of the cutaneous respiration. In that class of animals it is highly developed, both to serve as an integument to keep in their high temperature, and in consequence of their aerial life, and the velocity of their motions required in the attenuated medium. It is also developed as an organ of progressive motion of great lightness and density, as we see in the quill-feathers of the wings and of the tail. The colours even which the feathers present are interesting in a zoological point of view. In the arctic regions, covered with snows and ice during the greater part of the year, most of the birds that frequent those cold regions have a white and uniform colour. By this they resemble the white snow around them, and are concealed both from their foes and from the living prey upon which they are to subsist. As we advance to more temperate climates, the colours increase in number, in variety, and in intensity; yet not, however, presenting those brilliant hues of the plumage that are developed as we advance to hotter latitudes. The metallic lustre is at length gradually introduced along with the more brilliant and lively colours of the plumage; and as we approach to tropical climes, we find that the birds rival the insects and the flowers, that display as manifold and beautiful colours all around. Thus we see the surface of the humming birds, the parrots, the birds of paradise, and many others, covered as with precious gems, and with lustres that rival the polished surface of the precious metals. Now these light tubular instruments of motion have their solid horny matter disposed, as in the long bones of quadrupeds, for strength, in a hollow cylindrical form, and they shoot at first like tufts of hairs from the surface of the skin. Their lateral parallel flat fibres develop with their flat surfaces applied close to each other, and are hooked together by their fimbriated curved margins, so as to present a compact surface to strike the air. The parts of these feathers are formed in membranous capsules, and gradually protruded from the skin as they are developed, their bulbs, like the bones, being at first filled with a liquid, which is at length absorbed, to give place for the admission of air to lighten and harden these tubular horny instruments of flight. Their source of nourishment is ultimately cut off, their connexion with the skin becomes absorbed, their colours fade, and they are cast and renewed like the hairs of quadrupeds.

All the tegumentary organs are most distinct from each other in the class mammalia, as are all the other systems of their economy. The true skin presents every intermediate condition between the thick covering of the rhinoceros and the hippopotamus, and the delicate covering of the human body. The rete mucosum is most obvious where its colour is deepest, as in the dark varieties of our species; and the exterior cuticle varies not only in every species, but in every different part of the same body, according to the pressure or friction to which it is to be exposed. Like the feathers of birds, the hairs grow from a membranous sheath beneath the skin, and are nourished also by a pulp. Their extremity is protruded as its structure becomes perfected within, and, as in the feathers, the exposed part is extravascular, insensible, and incapable itself of growth or reproduction; but a fresh portion is continually protruding as the exterior is worn away; and we observe the same mode of growth in the nails and claws, formed between folds of the skin, and in the agglutinated hairs which compose the horns of the rhinoceros, and in the permanent horns and the hoofs of quadrupeds, and all the other epidermic developments which protect the surface of their body. The distribution of colours on the fleece of quadrupeds, and its density and compactness, obey the same laws as are observed in the plumage of birds, and the tegumentary organs of most of the inferior tribes. The white fleeces of the arctic-fox and the polar-bear, and the alpine-hare, are best suited to their habits and their habitats; and the same is the case with the dark covering of subterranean moles, or of nocturnal animals, as bats and rats and mice. The reddish-brown fleeces of lions and pumas, and caracals and tigers, and most of the feline tribe,

resemble the decayed leaves, or the light of the setting sun, or the sandy plains on which they lie in watch for their prey. I have found the spotted skin and the spotted fleece already obvious in the axis-deer dissected from the uterus. The metallic lustre, so rare in quadrupeds, is splendid in the chrysochloris. The hairs of quadrupeds are deciduous, like the plumage of birds; when their growth is completed and terminated, their bulb and their pulp are absorbed, their colour fades, they shrink and fall from the skin.

Such are the forms of the tegumentary organs appropriated to the different classes of animals, and such are the various systems of organs which are assigned to animals for their individual nutrition, and to establish their relations with surrounding nature.

LECTURE LV.

ON THE GENERATIVE SYSTEM IN THE RADIATED OR CYCLO-NEUROSE CLASSES.

The organs of nutrition and of relation, which we have been hitherto considering, enable the individuals of species, for a limited time, to live, to grow, and to feel; but while myriads of individuals appear and disappear, like passing shadows in rapid succession, the species, or the typical forms of groups of animals, are still prolonged on the earth. The species, however, like the individuals which compose them, have also their limits of duration. The life of animals exhibits a continued series of changes, which occupy so short a period, that we can generally trace their entire order of succession, and perceive the whole chain of their metamorphoses. But the metamorphoses of species proceed so slowly with regard to us, that we can neither perceive their origin, their maturity, nor their decay, and we ascribe to them a kind of perpetuity on the earth. A slight inspection of the organic relicts deposited in the crust of the globe, shows that the forms of species, and the whole zoology of our planet, have been constantly changing, and that the organic kingdoms, like the surface they inhabit, have been gradually developed from a simpler state to their present condition. These slow changes are regulated by the laws which preserve individual forms, and check the transmission, by generation, of modifications suddenly induced. Although no animal can exactly produce its like, the progeny are so nearly such, that, for all the purposes of science, we regard their forms as identical with those of the parent, and out of an indefinite series of such generations, and of individuals as nearly resembling them, we frame our organic species, and ascribe them to nature. All forms of matter appear to have a capability and a tendency to become organized, as all organic forms tend to higher stages of development, and chemical analysis shows the highest as well as the lowest forms of organic beings to consist of a complicated aggregate of mineral gases and liquids and solids. These organized aggregates once formed from their elements, all possess alike the means of transmitting their forms by generation, which is effected by the separation of a portion of their substance, when their own development is completed. But although this function is the most universal in organized beings, and often requires a complicated system of organs for its performance, we observe the lowest tribes of animals to possess the means of continuing their race without a trace of distinct generative organs. In the polygastric animalcules we commonly observe the simplest mode of generation, where the parent body spontaneously divides, and each portion assumes the form of the entire animal. This *fissiparous* mode of generation gradually leads to the *gemmiparous*, which is common to most of the higher radiated classes, and in which distinct portions are developed from the body of the parent, which become detached, and assume the entire form. In most of the higher classes, from the radiata to the mammalia, the generation is *oviparous*, where the germs before their evolution are detached from the parent body, surrounded with membranes, and enclosed in a sac of nutritious matter provided for their development in the embryo state. In the *viviparous* mammalia the ovum is early hatched within the body, and the embryo advances to a higher stage of development, by again becoming organically connected with the parent, before it is finally detached to assume an independent existence. All these forms, however, are but different stages of the development of the embryo before its final separation from the parent, and they severally accord with the condition of the organization of the parent body, and with the situation it occupies in the scale of beings.

In the most dissimilar forms of polygastric animalcules, the fissiparous mode of generation is distinctly perceived, and it often takes place in species which are also capable of producing by the development and separation of gemmules. The division of the body most frequently takes place in a transverse direction, often in a longitudinal, and in some species we

observe the body to divide at one time transversely, and at another in a longitudinal direction. They divide only when they have attained their mature dimensions, and with greater quickness and frequency the more they are nourished. When the division is about to take place in a transverse direction, the whole body lengthens, a transparency is observed across the middle, as if by the preparatory division of the stomach and parts within; and at length an indentation or contraction is perceived at each end of the transverse transparent line. The contraction extending inwards around the middle of the body, the animal appears as if composed of two smaller individuals of the same form, united end to end. The point of attachment continues to diminish till the two distinctly formed though smaller animalcules become detached, and no distinction of form or size can be perceived between them. Before their final separation I have several times observed both kolpodæ and trichodæ moving rapidly to and fro through the most crowded part of the fluid, and among the loose particles of mucous or other matters lying at the bottom, as if they sought to aid their separation by impinging against the surrounding objects. This is the common mode of generation in the *trichoda*, *cyclidium*, *kolpoda*, *kerona*, *enchelys*, and all the simpler monadine forms of animalcules. Several of the *kolpodæ* and *trichodæ* however, are observed at times to expand transversely, and to divide in a longitudinal direction, by the same process which at other times they exhibit in a transverse direction. The division in a longitudinal direction proceeds generally from one extremity of the body to the other, sometimes from the posterior and sometimes from the anterior extremity, to the opposite end. The *vorticellæ* are observed to divide in this longitudinal direction, from before backwards; their bell-shaped body expands transversely, their doubly-ciliated circular free extremity divides into two, the division extends through the body to the peduncle, and the bell-shaped portions, when completed, escape from their base, leaving the peduncle to perish. This fissiparous generation, common in animalcules, was considered by Lamarck and others to be incompatible with the existence of internal organs, and was employed as an argument in favour of their internal homogeneous composition, and their nourishment by superficial absorption.

Many of the polygastrica are capable of a gemmiparous mode of generation, and the reproductive gemmules are sometimes developed internally, and sometimes on their outer surface. In the *volvox*, the gemmules are developed from the internal surface, and escape by an aperture from the parent sac, when they become free, and have attained the condition of structure necessary for their independent existence. We can often perceive generation within generation in these animals, by looking through their transparent parietes. The *vorticellæ*, *kronæ*, and other genera, are observed sometimes to produce small gemmules from the exterior surface of one end of their body, the anterior in the kerona, and the posterior in the vorticella, and these gemmules, gradually increasing in size, and acquiring the form of the parent, become detached from its body and assume an independent existence. Baker, Gleichen, Ehrenberg, and others, consider the polygastric animalcules as capable also of a true oviparous mode of generation, and you will observe in these figures of Ehrenberg the *kolpoda cucullus* represented as in the act of expelling from the anal orifice a mass of ova enveloped in a fine reticulate substance. Where individuals of known species are seen with dimensions smaller than those commonly produced by the fissiparous or the gemmiparous modes of generation, that distinguished naturalist considers them as having been developed or hatched from ova, as we see the young developed in rotifera and higher classes, and he regards the minutely granulated appearance of the interior parietes which we perceive in the *kolpoda*, *paramecium*, and other large animalcules, as produced by their reticulate ovaria distributed around that part of the body. Some of the larger animalcules have been kept isolated for five or six days without dividing or producing in any other way, and then have divided twice or thrice in one night. From the rapidity of the successive divisions of the body observed in the polygastrica, it is computed that one individual in seven consecutive days might produce a million by this mode of generation alone—a fertility surpassing that of all other known organized beings.

The poriferous animals present an internal gemmiparous mode of generation in all the species in which this function has been examined. The gemmules are developed in the deeper parts of the parenchymatous or soft cellular substance of the body, between the parietes of the internal canals. In the species of our own coasts, the gemmules make their appearance in the earlier part of the winter, when the cellular or gelatinous matter is also most abundant throughout the whole animal. These reproductive bodies at first appear as minute opaque yellow points irregularly distributed in groups at a dis-

tance from the porous and absorbent surface of the body. As their development proceeds, they increase in number, they become larger, more opaque, more consistent, of a livelier yellow colour, and from being minute round points, they assume a more regular ovate form. In about two months after they are first perceptible, the greater part of the gemmules have completed their ovate form; they are detached from their connexion with the cellular tissue of the parent animal, and they are quite perceptible to the naked eye, being about the fifth of a line in length, and the tenth of a line in breadth. These ovate portions of the gelatinous substance of the parent are ciliated over their whole surface, excepting over their posterior tapering extremity, and when we examine them, before their maturity, in sections of the animal, we observe them attached, by this tapering unciliated portion, to the internal parietes of the deeper canals, while their ciliated portion is free. Those little reproductive bodies, at first of a round form, more pellucid, and almost gelatinous in their texture, assume gradually this consistence and ovate shape as they advance to maturity, and they are seen to communicate with the interior of the canals that ramify through the body. They are seen protruding from the gelatinous parietes of those internal canals into their interior cavity, and upon directing the microscope to their wider rounded surface, which is free, that exterior surface of the still undetached gemmules is seen to be covered over with cilia that are in constant rapid vibration. Thus these gemmules assist in their own separation and final expulsion from the parent, as in zoophytes. The rapid action of those cilia tends to pull them from the surface, to lengthen their form, to aerate and develop their structure, and to disengage themselves altogether; the streams that are constantly rushing in through the pores, and out from the vents, carry away from the interior and from the surface of the parent, the reproductive gemmules destined to continue the race. The soft gelatinous moving gemmules of the porifera, when newly detached from the body, are found, in the common halina panicea of our coasts, to contain already siliceous spicula developed within their interior. They continue, after their expulsion, to move to and fro in the water by the rapid vibrations of their cilia for a limited time, when they at length fix themselves in the position best suited for their future development, and which is peculiar to each species; some, with prominent papillæ, growing best upon a perpendicular or an inclined surface, some, without papillæ, upon the under surface of oblique or overhanging rocks; and some, with delicate branches, hanging from the lower surface of an inclined plane. The whole surface of the body in those reproductive gemmules is not, as in those of zoophytes, covered over with vibratile cilia; it is covered with cilia over all the anterior part to about one-third from the tapering posterior extremity; and in watching them beginning to fix on watch glasses, under the microscope, we find that a part of the unciliated surface first touches and fixes on the watch-glass, when the whole of the gemmule spreads itself out on the glass, and grows in the form of a flat motionless film. When it is thus fixed by its tapering extremity, and beginning to spread out, the cilia are still observed continuing for a short time to vibrate, and they now clear away by their rapid action the particles of loose or floating dust at the bottom of the glass, on the surface upon which they have to spread and to grow. When they have spread out into a flat extended transparent film, we can see the gradual appearance of newly-formed spicula, both in the central cellular tissue of the body, and in the more transparent homogeneous margin of the growing animal. Those spicula appear suddenly in their places, at once fully formed, and are not at first seen as small fibres that increase by the gradual addition of matter around their circumference —those minute crystalline spicula that form the skeletons of most of the poriferous animals. Those crystalline bodies have a definite arrangement in the developing body, which is not perceptible at first, when they are few and isolated; but when the pores make their appearance, and the fecal orifices become visible on the surface, all manifest a perfect harmony of arrangement; all that at first appeared to be thrown zig-zag in confusion through the gelatinous growing membrane, at length manifest great symmetry and method in their distribution, with relation to the pores, canals, and orifices. The gemmules, while free and swimming by the spontaneous movements of their cilia, appear to be sensitive to light, as they are observed to accumulate and fix chiefly on the dark or shaded parts of the vessels in which they are placed, and they are probably guided by the influence of light to the most proper situation for the different species to adhere to and to grow. They present no external aperture nor internal cavities while they are in this free condition of infusoria, their motions are equal, smooth, and gliding through the water, and they appear to be conscious of each other's presence, when they approach

near to each other in swimming, as they are sometimes observed in such circumstances to arrest their course and to swim for a short time round each other. They appear, by their constant gliding motions, to seek for a suitable place for their future development; but we cannot detect, nor even conceive, those mysterious laws by which their movements are so wisely regulated.

The zoophytes, like the porifera, are gemmiparous animals, but they present a great variety of distinct forms of this mode of generation. They present no distinction of sex, they are all productive, all female, like the other radiated classes, and like all the so-named hermaphrodite invertebrata. Some develop the gemmules externally, in others they are produced within the body of the parent; but whether the reproductive bodies are developed on the surface or in the interior, they are still sac-less portions, or naked embryos, detached from the parent, in a condition capable of gradually assuming its form, or after they have already acquired it. The simplest external form of gemmiparous generation is presented to us in the common fresh-water polype or *hydra*, which abounds in our stagnant ponds, and in similar situations in most parts of the globe. That isolated polypus, or simple digestive sac, with a variable number of prehensile arms extended from around the orifice, shoots out little buds from the middle of its exterior surface. Those minute fleshy buds extend, and at length form the same kind of hollow sac, and from around its margin small arms begin to bud out; and so a distinct new being, like the parent body, is developed, and remains for a limited time in connexion with the surface. Sometimes this bud is detached in the undeveloped condition of a round globule in the *hydra*. The animal is also capable of dividing its body transversely into two beings, like the fissiparous polygastrica. The newly-developed generation of external buds will sometimes be observed to develop a second generation from their surface, before they themselves are detached, as we see developed within the body of the volvox among the animalcules. I have observed the little *hydra* tear itself from the parent body while in a glass of fresh water. The parent animal attached to the side was moving towards the lighted side of the vessel—their accustomed movement—one of the young already developed, and still attached to the surface of the parent, fixed its little mouth to the surface of the glass, the parent body continuing on its march, by fixing alternately its caudal and its oral disk, like a leech creeping on the same surface; the young and the parent pulled in different directions, and thus the two were torn asunder; the little one continued its motions, and was now compelled to provide for itself. We observe thus, frequently, several generations of those little hydræ all united together, and forming a ramified fleshy aggregate of simple hydræ, like ramified vorticellæ. This simple mode of external gemmiparous generation is found to take place in the hydra, whether you turn it outside in, or leave it with its surfaces in their ordinary position. If you turn it outside in, when the animal is thus inverted, the digestive becomes the generative surface, and what was before the generative surface now becomes the digestive. These remarkable properties show the extreme simplicity of the whole organization, where all portions of those animals possess the same properties, and are capable of exhibiting the same vital phenomena. You can almost mince to atoms this simple digestive sac, composing the hydra, without destroying its vital properties, and its remarkable powers of reproduction. In the actinia the gemmules are developed within the body, and I have often dissected them out, completely formed, from the body of the small *actinia rufa*. They were almost colourless and transparent, and had four or five tentacula already developed.

A more complex form of gemmiparous generation is seen in those ramified horny tubular zoophytes, where the fleshy substance of the animal is contained in the interior of the horny texture, as in *sertulariæ*, *plumulariæ*, campanulariæ. At certain determinate points of the body, different but constant in each species, we observe, gradually protruded and developed in a soft condition, small and variously formed gemmiferous *vesicles*. In campanularia the gemmules are developed in capsules within the usual vesicles. Those vesicles sometimes come out from the axillæ or points of junction of the branches, and sometimes they are developed in the course of the branches, along with the cells of the polypi. They are at first soft, transparent, thin, and short sacs, with their horny exterior not yet consolidated; and a softer internal membrane, lining the whole, is filled with a thin colourless gelatinous substance which communicates with the fleshy part of the body. In the interior, at the bottom of this gemmiferous vesicle, the soft transparent cellular tissue soon assumes a more condensed appearance, and something is seen to be developing from that part of the vesicle next to the general fleshy portion of the animal from which it is always developed.

This organized portion at the bottom of

the vesicle extends upwards, carrying with it a narrow portion, like a chord, into the middle of the interior of the vesicle, and then the little gelatinous gemmules appear to be connected with the base of the vesicle by fleshy chords, called by Mr. Ellis umbilical chords. This connexion they keep up with the fleshy substance occupying the interior of all the ramifications until they are fully developed, until they have acquired their entire form, and have their minute vibratile cilia developed upon their surface; then the connexion is absorbed and lost, the fleshy substance composing the umbilical chords disappears, the gemmules, arrived at maturity, now move freely, by their vibratile cilia, in the interior of the vesicles, and the vesicle itself undergoes a change by which it is prepared for their escape. We observe that by the rapid and spontaneous action of the little vibratile cilia disposed around the surface of the reproductive gemmules, that they are prepared, by their own locomotive powers, to escape from the vesicle without the aid of any peristaltic or other motion from that capsule, which such a dense horny texture could not produce. The birth of these gemmules is their own act, and not the act of the parent; it is a beautiful provision in the inert bodies of zoophytes, which could not assist in the expulsion of the gemmules.

You observe that the capsule which contains the gemmules is closed at the free extremity by a transparent covering or operculum, which at length drops off, as in the oviferous capsules of gasteropods, and the passage is left freely open to the ingress of the water when the gemmules are matured; they feel the new stimulus of the external element, they are excited to more lively actions, their texture is condensed, they become perfected for their future motions, they escape from the vesicle, and swim about freely in the water by the rapid motions of their cilia, for a time; then they fix and develop, like the gemmules which have escaped from the orifices of porifera. The oviferous vesicle thus deprived of all its original contents, sometimes develops a polypus, but generally it is absorbed at its base, its connexion with the parent zoophyte is dissolved, it falls off, and leaves not a trace behind. So that those vesicles, like the seeds of plants, are deciduous parts, which here make their appearance at stated seasons of the year, generally in the spring on our coasts, and their forms are so different in the different species, that they afford useful zoological characters for their determination.

The *gemmules* are minute, round, soft, and highly organized ciliated gelatinous bodies in these tubular keratophytes. They move slowly to and fro, like animalcules, with, apparently, the design of sentient beings. They are here highly irritable; if they touch a particle of sand, or a fibre of any substance in their way, their bodies suddenly contract into a pyriform, or ovoidal, or some other shape. I speak now of the irritability of the swimming gemmules of the tubular polypifera; that phenomenon has not been witnessed in the ciliated gemmules of any poriferous animal. Those ciliated free gemmules thus swimming about with their highly-irritable bodies, changing frequently their form, contracting it in various directions as they glide along, continue their vibrations for a short time, until by some unknown means they are made conscious that they are touching a surface suited for their attachment; they are in the best position for fixing, and then they fix their bodies; they spread out in form of a flat and thin layer of cellular tissue, which has usually transparent thin margins, and the more opaque portion of the cellular tissue is seen in the interior of the spreading body. This continues to spread out as a thin film of irregular form over the surface of the watch-glass in which it is allowed to grow, and in those horny tubular species of zoophytes which are permanently fixed by a spreading ramified root, as these sertulariæ and *plumulariæ*, we observe that certain arrangements are taking place, of the particles in the interior of this thin gelatinous film that is spreading over the surface of the glass. Certain parts of the growing gemmule are soon perceived to have greater opacity than others, and those opaque parts, towards the centre of this spreading gelatinous substance, assuming a radiating form, the whole of the reproductive gemmule extends out at those parts of the margin where those radii appear to shoot out, and, consequently, the transparent homogeneous part which always bounds the exterior surface of the more opaque, continues outwards over the extending radii. In course of time we perceive distinctly that those more opaque and granular parts constitute the cellular internal living fleshy substance of the rays, and that the rays themselves are covered with a transparent, homogeneous, soft substance, that becomes condensed into the horny external tubular sheath. Watching carefully the development of the central fleshy part, and looking at it in an oblique direction, we can see that there is a slight central elevation where all the rays meet, that there is something like the stem of the zoophyte beginning to shoot up from the centre of these radi-

ating roots, and by holding it in an oblique direction, we can see that that stem is shooting higher and higher from the centre of those first-formed rays which constitute the roots, and that thus the roots, or parts of attachment in place of the polypi, are the first-formed parts which these spontaneously-moving free reproductive gemmules produce, after they have fixed and begun to develop; then the stem, then the branches, last of all the cells, and, in the bottom part of these cells, the polypi, are at length developed. So that the polypus, which Mr. Ellis imagined to be the first-formed part of these zoophytes, appears to be the last.

We observe nearly the same phenomena in watching the development of the gemmules in very different kinds of zoophytes. In the *flustræ*, which are cellular flexible membrano-calcareous zoophytes, the gemmules are developed in the interior of the same cells in which the polypi are lodged, and the polypi give place to them as they develop. The polypi themselves being thus forced to become deciduous, the gemmules occupy their place, develop, and escape, when mature, from the apertures of the cells, by the rapid movement of their cilia, showing that those polypi, which are here periodically deciduous, are not so essential to the existence or development of those animals as it was at one time conceived they were. Watching the reproductive gemmules of the flustræ, we see their vibratile cilia, their spontaneous motions, their fixing at length, and spreading like a gelatinous film, as in the other zoophytes. In the interior of the fixed and growing gemmule, we observe the white opaque calcareous particles, assuming gradually a form which presents the exact shape or outlines of a cell for a future polypus. From this single first-formed cell, we perceive, in the spreading gelatinous film which embraces its small opaque rays, extending from the outer margin, forwards and backwards, that those shooting calcareous rays in the spreading gemmule are parts of the adjoining cells of the *flustra*. At the bottom of the first-formed cell, an organization of a different kind is now commencing. The thin transparent cellular tissue is about to produce a rudimentary polypus. That polypus is still contained in a distinct small closed sac, with a transparent fluid around it at the bottom of the first cell. As yet there is no aperture in the membranous sac, nor in the enveloping cell. The first-formed cell could not, therefore, in these flustræ, and closely-allied zoophytes, be considered as developed or growing by the aid of a polypus, which is itself yet only in an embryo condition, enveloped in a membranous shut sac, and has no egress from its cell to seek for food, even if it were organized to a condition fit to seize it. This first polypus of the flustra gradually assumes all its parts; it becomes larger; its tentacula, and its anterior and posterior fibres of attachment to its cell, are developed. The little thin transparent membranous sac which encloses it extends upwards, and is found to line the whole internal parietes of the cell. An aperture is at length formed at the upper part of the cell, and then the polypus is sufficiently organized to extend itself from the aperture, and exert its little arms in creating currents for respiration and for food, by the rapid vibration of the cilia disposed along their sides. So that you observe here again, in a very different form of zoophyte, that the most inert parts are those which are the first result of the development of the gemmule, and not the polypus, which is the last part to be developed.

In some, and indeed in most of the higher forms of corticiferous and solid calcareous zoophytes, the gemmules pass through the bodies of their large and complicated polypi. We observe the same in this *lobularia digitata*, where we find eight clusters of small white round bodies making their appearance at the base of each of the polypi in the autumn. Those little round bodies, or gemmules, become gradually more white and opaque as they enlarge. At length they assume an orange colour, then they become redder, and, when fully grown, have a deep and bright-red colour. They successively detach themselves from the little white groups with which they were originally connected by filaments or umbilical chords. They escape thus into the body of the polypus, below its stomach. At the back part of the polypus, behind this open stomach, they are seen to be perfectly free, and to move and change their relative positions by the rapid vibrations of extremely minute cilia that cover their outer deep red surface. When the polypus is fully expanded, so as to enjoy the tranquil sea, there is a free passage of water through the stomach, from the mouth to the posterior extremity of the polypus, by the rapid vibration of the oral cilia, those of the tentacula not being vibratile. The sea water has free ingress through the stomach to the gemmules; the gemmules feel its influence, and advance; and as they approach the open posterior part of the stomach, they appear stimulated with new energy; they seek to enjoy that new stimulus; the aperture of the stomach behind seizes them; their cilia and all their motions are now for a time at an end. They are

conveyed through this open sac of the stomach, and, as we see also in actiniæ, escape by the mouth. Then their cilia commence again, and they move to and fro until they obtain a place to fix and develop, as in other species.

Nearly the same structure and phenomena were observed by CAVOLINI, in the madrepores, in the *caryophyllia*, and this appears to be common to most of the larger solid calcareous zoophytes; but CAVOLINI considered their gemmules as escaping by marginal openings between the tentacula of the polypi. In the *pennatula* and *virgularia* we observe gemmules which pass through the same phases of development in acquiring consistence, opacity, magnitude, colour, sphericity, freedom from attachment to the parent, and a ciliated surface to carry them through the bodies of the polypi, and, for a limited time, through the waters of the sea.

The lively-coloured internal bodies, of various hues, which we observe in the summer and autumn, shining through the transparent central parts of the acalepha, while they glide smoothly through the still seas, are closely allied in all their known properties and phenomena to the reproductive gemmules of zoophytes, and not to the ova of higher classes. They are minute round portions of the gelatinous substance of the parent which has no trace of sex, or means of impregnating ova; they present bright colours when mature, like the gemmules of inferior classes, being sometimes yellow, or orange-coloured, or purple, or bright red; and they have been long known to possess spontaneous motion when separated from the body in the *cyanæa aurita*, as mentioned by ROSENTHAL. I have observed the same spontaneous motions in those of the common rhyzostomes of our coasts; and in the bright-red spherical gemmules discharged from a minute *equorea* of the Thames, I could perceive not only the slow gliding spontaneous motions, but through the microscope I could also detect a finely ciliated zone in rapid action around their circumference. The two clusters of gemmules have the same bright-red colour, extending along the sides of the intestine in this *beroe pileus*, which contrast beautifully with the blue transparent texture of the animal. Those ovate gemmules are suspended in ramified groups from beneath the air-vesicle of the *physalia*, as we see them developed around the free margin of the mantle in several *medusæ*. Magnified views of these ovate gemmules of the *physalia* you observe in these recent plates of OLFERS, representing the various organs of that interesting animal. According to CHIAJE they form a single granular group in the *cestum*, placed at the end of the mesentery, and in the *velella* they pass out by little white tubes between the tentacula. In the four lively coloured reddish-brown gemmiferous clustres developed from the partitions between the respiratory and the digestive cavities of the *rhizostoma Cuvieri*, EYSENHARDT observed that the minute component fusiform bodies, which he regarded as obviously connected with generation, possessed distinct spontaneous motion, both before and after they had severally detached themselves from their peduncles. He considered these small generative bodies as capsules filled with a fine grenular or cellular matter, and has figured them as such. When CAVOLINI first observed the spontaneous movements of the gemmules of zoophytes after they had escaped from their open vesicles he considered them, and described them, and figured them as capsules singularly animated, and filled with minute generative globules, which escaped by the bursting of the capsules; but he soon afterwards corrected his mistake on finding that these supposed gemmiferous capsules, endowed with spontaneous motion, are the gemmules themselves.

In the echinoderma we find a more obvious and a more complex structure of the generative system, but still presenting no distinction of sex, all produce alike. In the asterias we observe in each of the radiating divisions of the body, whatever be their number, two ramified, glandular and highly vascular sacs, attached to the upper surface of the skin, that produce, at the commencement of the winter season, little round bodies that are discharged by small orifices around the mouth or entrance to the stomach. In the *echinus* we perceive also glandular sacs, five in number, and filled with small round bodies. These sacs are situate in the upper portion of the cavity of the shell, and open each by a short separate duct, which penetrates the outer angle of the large genital calcareous plates disposed around the anus. These ovaries were observed even by ARISTOTLE to be very early developed in the *echinus*, and they were used as food in his time as in ours. The large group of long convoluted and ramified tubular cæca seen in the anterior portion of the body of the *holothuriæ*, is their so-named ovary, which greatly enlarges, as in the other echinoderma, at the season of reproduction; and all its divisions are then found filled with a reddish viscid matter, which envelops all the minute developing germs. At other seasons this ramified generative organ is found to contain a thin white fluid, and its duct opens by a small

round orifice, protected by a transverse fold, on the surface of the skin, at a short distance behind the mouth. Several small glandular cæca communicate with this oviduct before it opens on the surface, which have generally been considered as impregnating or male organs. In the beginning of winter the little brown-coloured lengthened germs are found, a line long, in the viscid matter of the ovary, which has now enlarged to many times its ordinary size.

Thus we observe, that throughout the radiated classes, all the individuals are organized alike to perpetuate their race, and they are not only all productive, all female, but their fertility surpasses that of all the higher orders of animals, so that they are not less remarkable for their generative than for their digestive powers. In the fissiparous animalcules the whole body may be considered as generative, and the life of the individuals appears thus to have no end. The generative portion of the body is scarcely more limited or more defined in the class of poriferous animals, where the gemmules pour out in thousands from the interior of a single individual, which survives for several seasons. In the zoophytes, the parts of the body appropriated to reproduction are almost as numerous, though now more determinate in their position, and in the higher forms of acalepha and echinoderma, where the generative portion of the body becomes more and more limited and defined, a distinct organ is at length developed, to which alone the whole function of generation is appropriated, and which becomes more and more complicated in its structure, and divided in its function, as we ascend through the higher grades of the animal kingdom.

LECTURE LVI.

ON THE GENERATIVE SYSTEM IN THE ARTICULATED CLASSES.

Next in fertility to the radiated tribes of animals we find the classes of articulata, where the generative organs are more circumscribed and defined, and where sexual distinctions and the oviparous form of generation are gradually established. The fissiparous animalcules cast off their successive generations, heedless of their future existence; and the higher gemmiparous classes of radiata produce periodically their crops of reproductive gemmules, like the seeds of plants, and trust their safety and development to nature: but now complicated instincts, connected with generation, begin to manifest themselves, and to provide for the progeny beyond the period of its attachment to the parent. The sexual distinctions, and the high development of the generative system, are not less remarkable in the articulated classes, than the predominance of their animal over their organic functions; but from the mystery in which the whole function of generation is involved, it is easier to perceive the increasing complexness of the organs, than to assign uses to the various parts, and it is perhaps from this circumstance that we can discover less evidence of unity of plan in the composition and forms of their generative apparatus, than in almost any other part of their economy.

In the lowest articulated classes, we still find many animals without organs of impregnation or excitement, and which, like all the radiated tribes beneath them, are self-productive, and without a trace of sexual difference. The cystic entozoa, as the cysticercus, the cœnurus, and the echinococcus, appear to have an internal gemmiparous mode of generation, like the volvox among the animalcules. They present no organs appropriated to this function, but minute gemmules are observed to develop from their interior parietes, which, after assuming the perfect form, become detached, and are found floating loose in the contained fluid of the parent sac. The long articulated flat tænioid worms possess in each segment an ovary, which is sometimes long and with radiating ramifications, and sometimes of a simple round form. This ovary occupies the central portion of each joint of the body, and terminates in the lateral pore by a distinct oviduct. There is also a small glandular sac in each segment, which communicates with the extremity of the oviduct, and which some have imagined to be an impregnating organ. The termination of the oviduct is prolonged outwards as a stiliform tube, and forms the supposed penis; but as all the segments are alike generative, they probably possess only organs belonging to the female sex, as all other supposed hermaphrodites. The generative organs of the distoma hepaticum, like each segment of the tænia, possesses a ramified and complicated ovary and a lengthened oviduct, with which a long and tortuous secreting tube, regarded as a testicle, is found to communicate. The ovary here occupies the circumference of the body, and the supposed testicle the central part: they open together at the lower and anterior part of the body, immediately behind the mouth. The ova, viewed through the microscope, appear as thin sacs, filled with regular spherical and

minute granules, and the ovaries, viewed in the same manner, appear composed of clusters of aggregated ova, throughout all their ramifications.

In the long cylindrical forms of the acanthocephalous and nematoid entozoa, the sexes are distinct, and placed in different individuals, and impregnation takes place internally, as we see in the echinorhynchus and the ascaris. The female organs of the ascaris consist of a long ovary, or bifurcated tortuous glandular sac, which terminates externally on the ventral surface by a single orifice or vulva, about one-third way from the anterior extremity of the body. From this vulva we observe the ovary to descend and to enlarge, then to bifurcate, to continue for a considerable distance wide, and then gradually to contract and become filiform. These two long narrow tortuous portions of the ovary are coiled round the alimentary canal in all the posterior half of the animal's body. In the male of those worms the testicle presents a single long small filiform sac, which is convoluted round the intestine, like the ovary of the female, and it terminates in a styliform tubular process, which extends outwards at the posterior extremity of the body. That styliform tubular organ of intromission, continuous with the end of the long convoluted testicle, is inserted into the vulva, in the female, in the act of impregnation already in these lowest of the helminthoid classes of animals. I have found thousands of young, perfectly formed, in this convoluted long tubular ovary of the common *filaria medinensis* or guinea-worm, which is so often found in the cellular tissue of the ankles and legs of persons who have had these parts exposed by night in the east of Asia; so that the surgeon uses great caution in extracting the worm, not to break its body, which would fill the wound with living young from the ruptured ovaries. In those remarkable parasitic worms which attach themselves to the exterior parts of animals, as the *lernææ*, the *chondrocanthus*, the *achtheres*, and many others, the sexes appear to be generally distinct, and placed on different individuals; the generative organs and the phenomena of generation closely resemble those of entomostracous crustacea, and the young pass through similar metamorphoses of form during their development. The two ovaries extend along the sides of the alimentary canal, and open below into two long pendent external sacs, into which the ova are conveyed when mature. In the blighted ova of these sacs, of which there are sometimes observed two or three, while the rest of the ova are advancing in their development, monads have been seen in active motion before the enveloping tunics have been opened, and the same animalcules are seen alive in the body of the living diplostoma. The young of the *achtheres*, as they appear when developed in the ovum, and immediately after their escape, have the form of monoculous crustacea of the genus cyclops. The same entomostracous form is seen in the young of the tracheliastes, where they also have the shape of a cyclops on escaping from the ovum, and the future changes during the metamorphoses are chiefly produced by the development of the posterior parts of the trunk and the organs of generation. The young of the *lernæocera* have also been shown by Nordmann to possess the form of monoculous crustacea on first coming from the ovum.

We have already seen many affinities to exist between the rotiferous animalcules and the helminthoid articulata, in the most essential parts of their structure, and we see them also in the forms of the generative apparatus, and in the whole phenomena of that function. They are all productive, or female, and their organs present that form which is commonly termed hermaphrodism in the lower tribes of animals, where certain glandular organs, considered as impregnating, open into the course of the oviducts, so as to affect the ova before their expulsion from the body. We observe two long and wide sacculated ovaries in the cavity of the abdomen, extending upwards along the sides of the stomach, and communicating with each other below, where they open by a common orifice into the terminal or cloacal part of the intestine. From the great transparency of the body, the ova are seen developing in these wide sacs; the forms and the parts of the young are distinctly seen while yet within the ova, and the ova are often hatched before escaping from the body. The mode of connexion between the embryo and the ovum, and the mode of nutrition of the embryo, have not been distinctly observed in these wheel-animalcules, but they come from the ova with all the external characters of the parent. Behind those ovaria, or the bifurcated ovarium, we observe another lengthened narrow sac on each side, each of which communicates at its posterior or lower part with an enlarged thin membranous receptacle. That large posterior sac communicates at its orifice with the open termination of the oviduct, where it enters the cloacal part of the intestine. Now it has been considered in animals where a structure like this presents itself, that that glandular sac which pours its secretion into the oviduct, is a male organ, and that such animals are hermaphrodites; but this

function of the supposed male organs, and the existence of such hermaphrodism as a normal character in animals, have not been shown by direct observation, or by experiment, or by the analogy of other known structures. Our ignorance of the function of such glands, opening into the oviducts, where all the individuals have distinct female organs, is the principal reason adduced for supposing them to be male organs superadded to the female organs on the same beings, and so hermaphrodites have been made to exist as low as the holothuriæ and other echinoderma. In insects and many other animals, where the sexual differences of the generative organs are distinctly established, and where the male and the female are separate individuals, we still however find numerous glands communicating with the oviducts, which superadded glands no one ever regards as male organs.

From the fixed condition of the cirrhopods they require to possess the means within themselves of continuing their race, and we find all the individuals of each species to be organized alike in their generative organs, and all capable of producing young. Their ovary on each side occupies a large part of the abdominal cavity, extending from the liver to the syphon, and placed along the anterior or concave portion of the trunk. The ova, collected by a narrow duct from each ovary, are conveyed into a long, wide, tortuous, and glandular portion of that duct, which is regarded as a testicle, and is thought to impregnate the ovary as they pass through it. From this thickened glandular terminal portion of the oviduct, on each side of the digestive organs, the ova pass into the base of the syphon, through which they are conveyed out from the interior of the body, like the other excretions; but after their complete separation from the two ovaries and oviducts, they are still retained within the cavity of the shell, collected in groups beween the inner surface of the mantle and the body of the enclosed animal, as we often see both in articulated and in molluscous animals. In this situation the ova are protected, aërated, and developed, till they are in a condition fit to be discharged from the shell. In the lepades they are found free at the bottom of the cavity of the shell, and in the analifæ they extend free into the peduncle.

Even in the free and highly-organized annelides, we still find all the individuals of each species to be alike organized with relation to the generative function. Some of the lowest of these worms, as the *stylaria paludosa*, have been observed spontaneously to divide transversely into several distinct portions, each of which had, previous to their complete separation, assumed the form of the entire animal. The internal organs had become constricted and divided, as in the fissiparous animacules, and the external appendices of the head and tail were developed from the terminal segments of each portion, before they assumed an independent existence.

About a third from the anterior extremity of the common earth-worm, we observe a short enlarged portion surrounded by wider segments, and containing the generative organs, which consist of six small round ovarial sacs, and four similar glandular bodies, regarded as the testes of this animal. Mutual intercourse or excitement is observed here to precede the development of the ova, and they are regarded as hermaphrodites impregnating each other by lateral minute openings at the dilated portion of the trunk. Small oval masses of aggregated ova are observed, quite free, between the integuments of the body and the alimentary canal, in the lower or posterior part of the animal, and, after attaining their full development, in descending along the body they are hatched in the posterior part, and the young escape through the anal termination of the animal by two small orifices, a mode of generation similar to that ascribed to the lampreys. Near the middle of the body, on the abdominal surface of the leech, there are two minute orifices, the one a little before the other, which belong to the generative organs. The anterior opening transmits a long narrow tubular duct from two long convoluted glandular tubes, which appear to commence from nine small round vesicles on each side, and regarded as testicles. This exsestile tubular organ of excitement is considered, generally, not as a clitoris but as a penis, and the internal ducts and vesicles are looked upon as seminal ducts and testicles in these so-named hermaphrodites. The posterior of these two small openings leads to the common opening of the two oviducts, extending from the ovaries, and is the passage through which these females receive mutual excitement for the development of their ova. The pontobdella muricata deposits its ova separately, attached by small peduncles to the surface of submarine bodies; they are covered externally with a tough opaque greenish capsule of a round form, and with two lateral openings filled up with a transparent substance, which hardens by the action of the external element. There is thus a small operculum at each side of the ovum; and the whole capsule, at first soft, becomes dense in its parietes by the action of the water, when it is de-

posited from the worm upon the solid substances at the bottom of the sac. It contains at first a thin transparent saltish colourless gelatinous fluid, that is observed to develop a small transparent worm in its interior, with the same tuberculated surface, and of the same form, as the parent. That young worm is seen to be formed gradually from this gelatinous substance of the ovum, of considerable size, transparent and colourless, and its orgnanization to be gradually manifested and perfected in its interior. The operculum at length drops off from each side, and allows the little animal to escape. These little round dark-coloured pedunculated ova of the common skate-leech, are often found attached in groups to the surface of oyster shells.

In the myriapods the sexes are placed in different individuals, and the organs of generation terminate towards the anterior part of the body; they are oviparous. From the position in which their genital organs open upon the surface of the body towards the anterior part, and not at the posterior extremity, as they do in insects, they present an interesting analogy with the helminthoid classes of animals. You have seen that that was the position of the vulva in the ascaris, in the leech, and in many other animals belonging to the vermiform classes. In the myriapods, however, the sexes are always placed on different individuals, and are marked by external peculiarities. In the chilognatha the ovaries open externally by two small mammillary eminences, without hooks, (which are present in the corresponding parts of the male) behind the base of the second pair of legs. The male organs do not make their appearance till these animals have attained a third of their full size; they consist of two testicles, which open externally by two papillæ, terminated by curved hooks. They impregnate like serpents, face to face, and with their bodies twisted round each other. But in the chilopoda the organs of generation in the female appear to be single, there being but one ovary and oviduct; the long single tubular testicle in the male being accompanied by several long accessory glandular follicles, as in insects. The single ovary of the scolopendra extends backwards above the alimentary canal, as a simple glandular tube, to open near the extremity of the rectum. The ova are developed from the interior secreting parietes of this long ovarial tube, and when detached from their peduncle they pass along the cavity of its upper part, to be discharged. The testicle occupies the same position in the male of this animal.

As in all the myriapods and arachnida, we find in the class of insects the sexual organs always placed on different individuals, and the two sexes often differ so much in their outward form, that they are scarcely recognisable as belonging to the same genus, or even to the same family or order of insects. The organs of generation have here been more carefully studied, and appear more complicated in both sexes than in the other articulated classes, and this greater complexness arises both from the subdivisions of the organs themselves, and from the number of accessory glandular tubes and follicles which enter into their ducts. They open at the posterior part of the trunk, and communicate with the cloacal termination of the intestine, as in most of the vertebrated classes of animals. They are double in both sexes, and symmetrically developed on the two sides of the body, but with single openings on the surface. The ovaries, like most of the glands of insects, consist of simple tubes, more or less lengthened and subdivided, and the two oviducts unite to form a common canal on the median plane before they reach the cloaca. The ova, in each tube of the ovaries, are placed in a single row, and, as in other animals where impregnation is internal, they are unequally developed, those next to the oviducts being the largest and most mature, and those above being the less developed and smaller, the nearer they are placed to the closed end of the tube in which they are formed. We generally find opening into the lower part of the common oviduct a short wide canal, from a large oval or round sac, which is considered as a receptacle for the injected fluid of the male to impregnate the ova as they descend, and this fluid is found to swarm with living animalcules. There are sometimes smaller vaginal receptacles and minute glands at the sides of the vulva, as shown in the melolontha, in these plates of Straus. In many species with long and convoluted oviducts, the ova are hatched within the body of the parent, and they present an ovo-viviparous mode of generation. The vulva is often provided with curved hooks to retain the male, and, with an ovipositor, to convey the ova to the situations best suited for their future development. The number of the divisions of the ovary on each side varies very much in different insects, there are commonly about six in each ovary, but sometimes there are more than ten times that number. The male organs present even more varieties of conformation than the female, and this diversity is often observed in species which are most closely allied in their other parts. The testes are generally formed by numerous long glan-

dular tubes, which pour their secretions on each side into a common seminal duct, and the seminal ducts unite to form a single vas deferens before they reach the organ of intromission. These seminal glands sometimes consist of groups of minute cæca, and sometimes they are short and wide canals, or small glandular vesicles, which pour their contents into a common duct on each side. At the point of junction of the two common ducts of each side there are commonly two or more distinct tubular sacs, sometimes very long and convoluted, regarded, from their situation, as vesiculæ seminales. The common ejaculating duct from these spermatic glands and vesicles enters the base of the penis, which organ of intromission has commonly two horny projections at its free extremity, for separating the sides of the vulva to admit the spermatic fluid. In the scuterella nigro-lineata the testes consist only of a single wide, short, glandular tube on each side, with a short vas deferens, leading to two very short, wide, round sacs, or vesiculæ seminales; and besides these there are also innumerable minute, short, tubular vesiculæ, disposed in tufts, and opening in the same part of the ejaculatory duct. In the *cetonia aurata* each testicle consists of twelve small, round, glandular vesicles, with separate ducts, leading to a common vas deferens, and at the point of union of the two vasa deferentia there are three pairs of small convoluted glandular tubes, in the situation of the vesiculæ seminales. In the *pentatoma smaragdula* there are three different kinds, and an incalculable number of these glandular tubes, named vesiculæ seminales; in insects there are two tufts of minute convoluted tubular filaments, two large, round, simple vesicles, and two groups of larger tortuous glandular tubes, and all these organs open into the commencement of the ejaculatory canal of the seminal fluid. These glandular accessory tubes vary more than any other parts of the male organs. Notwithstanding the great dissimilarity of the sexes in the adult insects, in their internal as well as their external conformation, the male and female sexual organs are found to be almost identical in form in the first period of their development in the larva, as we find in the sexual parts of vertebrated animals.

The sexual differences are generally less marked externally in the arachnida than in insects, and their internal organs are more completely double; the sexes are in different individuals, and the generative organs are symmetrically developed on the two sides of the body. The ovaries and the testes still present the form of tubular secreting organs, more or less subdivided, and they open externally by distinct orifices on each side. The ovaries of the scorpion consist of numerous short wide cæca, which communicate with two lateral oviducts, and with a third on the median line. These three oviducts communicate with each other by four transverse short canals, and they open on the inferior and posterior part of the alvithorax by two separate vulvæ. The ova are hatched in the cæca of the ovaries, and before parturition a single distinctly formed scorpion is found extended in each cæcum, with its long narrow tail lying next to the oviduct. The two testes of the male open externally by two distinct penes, corresponding in position with the two vulvæ of the female. The two ovaries of the spiders and tarantulæ lie towards the anterior and lower part of the abdomen; they consist of two short wide sacs, and open separately near the respiratory orifices. The parts considered as the male organs of excitement, concealed in the terminal joint of the palpi, have been often observed to be darted repeatedly into the two vulvæ of the female during the act of impregnation. In the mygale these two male organs of the palpi have precisely the form of a penis. Some of these animals, after enveloping their ova in a network of fibres, and attaching them to some solid surface, leave them to nature; others place them near to their cell, so as to watch and protect them, and others carry the enveloped mass of ova attached to their abdomen. The umbilical chord enters by the back part of the embryo.

In the crustacea, as in the arachnida, the organs of generation of both sexes are commonly double, both in their internal parts and in their external openings, and they terminate on the surface at a distance from the posterior extremity of the trunk. In the macrurous decapods the two ovaries are seen in the cephalothorax, extending longitudinally between the sides of the stomach and the lobes of the liver. They consist of two cellular glandular lengthened sacs, which extend backwards into the post-abdomen, and communicate with each other by a wide opening, before they terminate in the two oviducts. The two oviducts descend along the sides of the trunk to the haunches of the middle pair of legs, where they open on the ventral surface by two round holes, or vulvæ, commonly surrounded with projecting hairs. The mature ova discharged through these two openings are collected under the post-abdomen, and are suspended by glutinous filaments to the fringed edges of the false feet, till their development is completed. The umbilical

chord or yolk-bag here also enters the intestine, not by the lower surface of the animal, but by its dorsal or upper surface, the intestine being nearest to this surface, and the animal being inverted in all its parts in the ordinary position in which it rests or moves. The testes consist of two long glandular sacs, with a lengthened and convoluted epididymis extending from each. They are situate, as the ovaries in the female, near the sides of the heart in the upper part of the trunk, and each sends down its vas deferens to terminate in a long tubular exsestile and erectile penis, which is lodged in an open cavity at the base of the last or fifth pair of legs. In the brachyurous decapods, and all the lower orders of crustacea, even in the entomostracous tribes, the disposition of the genital organs is found to be nearly the same. In many of the entomostracous crustacea, the mature ova descend from the abdomen into two long pendent thin sacs attached to the posterior part of the trunk, in which they are preserved till the embryos are fully developed, as we saw common in lernæa, and many other forms of epizoa, which approach most closely to the crustacea.

LECTURE LVII.

ON THE GENERATIVE SYSTEM IN THE MOLLUSCOUS CLASSES.

The *ascidia* and the *oyster*, though more highly organized in all that relates to nutrition, can as little seek for a mate as the coral that grows beside them, fixed immoveably upon the rock. The slow-moving or fixed tribes of radiated animals, like the cryptogamic plants, are all generative or female, but the free and active articulated tribes, organized for life and enjoyment, we have seen to possess not only distinct organs of generation, but organs of excitement, and separate sexes, with all the complicated instincts which accompany those conditions of existence. From the imperfect development of all their organs of relation, and from their inert and often fixed state of existence, the lower molluscous animals are almost in the condition of zoophytes in all that relates to generation. The tunicated and conchiferous animals, for the most part enclosed in extra-vascular coverings, and attached immoveably to the surface of rocks, have no means of impregnating their ova by the concourse of separate individuals, and many molluscous animals, higher than these in the scale, are almost similarly circumstanced, from their imperfect means of locomotion, and the imperfect development of their organs of sensation and perception, by which the presence of the sexes, if they existed separately, might be recognised. In the lowest compound tunicated animals, as the aplidium and polyclinum, distinct organs of generation are already observed, in the form of a simple, glandular, ovarial sac, with a single oviduct, which ascends along the side of the intestine to open near the termination of the rectum. This single ovary lies commonly at the closed extremity of the sac; it is sometimes found empty, and sometimes filled with ova grouped together and attached by convoluted filaments. The lowest ova are the largest, and the young are sometimes seen distinctly developed in the course of the oviducts. In the *aplidium lobatum*, the ovary is a thin oblong membranous sac, at the closed extremity of the body, and generally containing about thirty round ova, which, when mature, escape through a small canal which ascends with the rectum. The ovary occupies the same situation, below the abdominal cavity, in the *polyclinum saturnium*, where it tapers to a slender tubular filament at its lower part, and it contains the ova, attached in a similar manner, by filaments or vessels. The spherical ovary of the *didemnum candidum* is situated higher on the left side of the cavity of the abdomen; and that of the *eucælium hospitiolum* on the right side, containing about five large ova, attached by their tapering ends around a central mass, as shown in these elaborate plates of Savigny. The ovary is double, however, in several of these compound tunicata, as the *pyrosoma* and the *botryllus*, as well as in several of the higher *ascidiæ*. These animals are designated hermaphrodites by Savigny, and so are all the other acephalous mollusca, although he admits that their germs are susceptible of development without previous impregnation. But if there are true hermaphrodites in this or other classes, we ought to find in such animals not only organs of conception, or female organs, but also some trace of those of impregnation, or of the male sex. In that elegant violet-coloured animal the *diazona violacea*, with all its component ascidiæ radiating around a central point like the extended tentacula of an actinia, we observe a single round ovary, surrounded by a fold of the intestine, and lodged in an inferior cavity, prolonged from the general cavity of the abdomen, and the oviduct ascends with the intestine to terminate near the anus. The large and single ovary of the *distoma*, with its regularly disposed straight rows of ova, is placed in a similar sac, below the abdomen; it is much more lengthened and

cylindrical in the *synoicum*, and it forms a long convoluted tube in the *sigillina*. The lower closed portion of this long convoluted spiral tube of the *sigillina*, secretes the ova, which are developed as they pass along towards the abdominal cavity, and the upper portion, forming the oviduct, terminates, as usual, near the anus. The animals composing the aggregate mass of the botryllus, though formed originally separate from isolated ova, appear, from the observations of SAVIGNY, to be already grouped together, as they are in the adult, before they escape from the body of the parent. This animal has two large round white ovaries placed on the sides of the abdominal cavity, and the mature ova appear to pass out through a long tortuous oviduct, to be collected in an aggregate mass before they are finally expelled from the sac. There are also two ovaries in the pyrosoma, placed forwards, near the respiratory orifice, and with two short and coloured oviducts; the ova pass out separately from the oviducts, but the young collect at the bottom of the sac, and are grouped together like the parent mass before they are discharged. Four of the fœtuses aggregated together in a circular manner, and developed to a considerable size, appear to escape on each occasion from the anal orifice of the respiratory sac.

In the boltenia, as in most of the simple isolated forms of tunicated animals, there are two ovaries and two oviducts. These ovaries are unequal, lengthened, lateral in their position, extended longitudinally, and provided with two short oviducts which open near the anus. The little granular masses composing the ovaries, in some of the *cynthiæ*, are very numerous, and are interposed in rows between the several folds of the branchial sac; but in all the *phallusiæ* this organ again appears single, with the oviduct running along the lower part of the rectum to the anus. It is single in the clavelina, and placed in a fold of the intestine at the bottom of the sac. The ova, in many of the higher ascidiæ, appear to be retained for a time in connexion with the branchial sac, as the ova of the conchifera are attached to the gills, to promote the development of the embryos; and CUVIER imagined them to be impregnated in this situation by a seminal fluid from an excretory duct near the rectum. Distinct male organs, consisting of a testicle and spermatic vessel, are given by CHIAJE to *salpæ*, *ascidiæ*, and other genera of tunicata, along with their organs of conception or female parts, but the function of all such supposed male organs superadded to the female parts in the same individual, are at least equivocal.

The inhabitants of bivalve shells are similarly circumstanced to the tunicated animals in all that relates to generation, and they present the closest resemblance to them in the form and disposition of their generative organs. The fixed condition of most of the conchifera, and their close envelopment in exterior shells, are incompatible with the existence of separate sexes; and we find that they are not only all alike, generative or females, but that their generative organs are of the simplest kind. The ovary, generally single, sometimes double, with two oviducts, occupy, for the most part, the anal extremity of the cavity of the abdomen. Placing these animals on their ventral surface, with their branchial laminæ hanging downwards, and their œsophageal opening, or mouth, directed forwards, we find the upper and back part of the abdominal cavity, above the expanded base of the foot, occupied with the mass of the ovary, sometimes round, conglomerate, and lobed in its form, as in the *mactra*, and sometimes of a lengthened and divided form, extended along each side of the rectum, and consisting of numerous cæca filled with ova, and leading to a common duct on each side, as in the cardium. The oviducts here, as in most of the tunicated animals, extend along the sides and lower part of the rectum, to open near the anus. In the solen, the large ovary, distended with ova, fills the whole of the lengthened and wide cavity of the foot, as well as the posterior part of the abdomen. The ova are at first transparent and homogeneous throughout, and at length the embryo appears, as a central, opaque, round, nucleus, surrounded with a colourless fluid. When the ova are at length discharged from the oviducts into the general respiratory cavity of the mantle, they become attached to the component parallel fibres of the branchial laminæ, where the little embryos are protected, aerated, and developed, till they are in fit condition to be discharged with the currents of water passing out through the respiratory vent, as we see the ova of crustaceous animals attached to the false feet, or to the external branchiæ, after they have been discharged from the oviducts.

By opening the ovary of the *mya pictorum*, under the microscope, POLI was delighted to discover several of the embryos so highly developed that they opened their little shells, and moved about briskly on the object-glass as soon as they escaped from their enveloping ova. The ova themselves taken from the ovary of the *pholas dactylus*, have the lengthened, conical, and truncated form of the adult animal. The large and deep-coloured ovary of the great *pinna nobilis* fills with its pinnate ramifica-

tions the whole periphery of the abdominal cavity, and as the ova enlarge in the divisions of this minutely ramified glandular sac, they encroach upon the abdominal viscera, and appear to surround the whole cavity of the abdomen with a continuous mass of aggregated ova. The ovary of the common muscle, *mytilus edulis*, situate on the upper and back part of the abdominal cavity, and of a light rose-red colour when the ova commence their development, extends its long and delicate ramifications, from a common trunk on each side, over the whole substance of the mantle, between the two parietes of that exterior musculo-secreting tunic of the body.

By the enlargement of the ova in that situation between its folds, the whole mantle becomes thickened, the ova assume a yellowish colour, and at length become white, when mature, and a profuse white-coloured mucous secretion is observed at this period to moisten the whole surface of the mantle and of the contained parts, which has been considered by Poli and others as a spermatic fluid, poured out to impregnate the ova contained in the innumerable ramifications of the ovary, and in their sacculated shut extremities. The blighted ova of these animals are regarded by Poli as the nuclei and origin of pearls, which are seen, like the white ova, adhering to various parts of the surface of this oviferous mantle. We observe the same extension and minute ramification of the ovary on each side of the body, between the parietes of the mantle, in its interior substance, in the *anomia*, the *ostrea*, and many other conchiferous animals, as is seen in the common muscle, by which means great space and protection are afforded to the swelling ova and the developing embryos, without much incommoding the viscera contained within the abdominal cavity. The ovary presents for the most part some lively hue during the development of the ova in these conchiferous animals, as we see also in most of the tunicata, and that colour changes considerably as the ova advance to maturity in the ramified sac of the ovary. Sometimes, as in the *pecten jacobæus*, we observe one portion of the ovary filled with ova of a very different colour, and in a different stage of development, from those which are contained in the rest of the organ. The ovary has commonly at first a bright red, or violet, or brown, or yellow colour, which becomes paler as the ova advance in their development, and the whole distended organ assumes a pearly-white colour when the ova are ready to be discharged. The oviducts of the two sides open by a single cloacal orifice into the respiratory sac.

Many of the gasteropodous mollusca are similarly circumstanced to the acephalous tribes, both in their incapability of receiving impregnation from without, and in the female character of their generative apparatus in all the individuals of the species. The slow-moving *patella*, as fixed in its calcareous pyramid as the oyster in its bivalved shell, has also equally within itself the means of continuing its race. On removing its large muscular foot from the lower surface of the abdomen, we observe the single ovary of great size occupying the whole of the left side of that cavity, the liver being chiefly confined to the upper and right side of the body. The ovary here, as in most of the conchifera, envelops a large portion of the alimentary canal; and when the ova are mature for delivery, the organ swells to such an extent as to occupy the greater part of the visceral cavity. The oviduct, single, wide, and tortuous, passes across the upper and anterior part of the abdomen, to open on the right side near to the anus. In the *chiton*, the long and lobed ovary extends along the whole upper part of the abdominal cavity; on the median plane, and towards the posterior extremity of the body, near the two divisions of the auricle, two oviducts are observed to extend transversely, to open, as in a cephalopod, on each side of the body. The genital organs have the same simple structure in the *fissurella* as in the common limpet, and the oviduct opens in the same manner on the left side, close to the anus. In these simple self-impregnating forms of gasteropods we perceive no trace of organs of excitement, or a clitoris, yet developed. This organ, which thus appears to be undeveloped and unnecessary in the self-generating cyclobranchiate and scutibranchiate gasteropods, is, however, distinctly formed in most of the higher orders of this class, where it has commonly been termed a penis, although it is associated only with female parts, and is the only organ of excitement developed in these so-named hermaphrodites, requiring mutual impregnation, as we see in the air-breathing or pulmonated gasteropods, and in the *tectibranchia*, *inferobranchia*, and *nudibranchia*, where the intercourse of two distinct individuals similarly organized is necessary to forward the development of the ova in each. These animals, and such as are similarly organized in other classes, are commonly termed androgynous, from their being supposed to possess the organs of both sexes united on the same individual—that is, all their genital apparatus double, a combination, however, which they are not observed to possess. We have already seen that in many insects where

the sexual organs are distinct, and placed on different individuals, there are often numerous pairs of glandular cæca, which communicate with the spermatic vessels and with the oviducts, as well as the testes and ovaria, and we cannot always perceive the analogies or the functions of the glands thus connected with the genital systems of the two sexes in these complicated forms. Now, in these so-named hermaphrodite gasteropods requiring mutual excitement, where all the individuals are alike generative or females, we commonly observe other glandular organs, besides the ovary, connected with their oviduct and with the clitoris. In the *aplysia* the large white-lobed ovary occupies the posterior closed extremity of the abdominal cavity, as in the higher classes of pteropods and cephalopods, and the long, wide, and tortuous oviduct, after receiving the ducts of several distinct glands, passes forwards to open on the right side of the body. The largest of these accessory glands is termed the testicle, and it presents a convoluted duct, like an epididymis. Another of these glands, in form of a simple sac, with a short duct opening nearer to the end of the oviduct, is considered analogous to the urinary organs. Most of the naked gasteropods, as the *eolis*, the *tritonia*, the *scyllæa*, and the *doris*, are observed, like the *aplysia*, to impregnate, or to excite each other, by a distinct organ of intromission, and this mutual copulation appears necessary to the future development of the ova in both individuals. The large ovary of the *doris*, single, as in most of these unsymmetrical molluscous classes of animals, is imbedded in the substance of the liver, and sends its long tortuous oviduct to open with the organ of intromission on the right side of the body—the most frequent position for the opening of the genital organs, both of the naked and the testaceous gasteropods. Several glandular organs of doubtful functions and analogies are observed here also to open into these two systems of genital organs. In the little elegant floating *scyllæa* the ovary fills the right and posterior part of the abdominal cavity, and has a round form, like the urinary sac, which so commonly accompanies this organ in the gasteropods. The testicle, as it is termed, is here divided into lobes, as in the tritonia, and the organ of excitement or intromission, is a long tortuous chord capable of extending, erect from the right side of the body. The lobed ovary of the snail is placed at the posterior part of the abdominal cavity, concealed by the large lobes of the liver, and the long narrow oviduct opens into a wide, long, sacculated cavity, termed the uterus with soft glandular parietes, where the ova appear to be collected and matured. The duct from this receptacle of the ova, and the duct from the two divisions of the testicle, enter the great generative sac at the base of the long erectile organ of intromission, which is extended in the same manner as the tentacula are projected from their sheath, when the two individuals advance with their right sides to each other for impregnation. The usual round urinary bladder is here present, and several multifid glandular vesicles pour their secretion into the same canal. The thin bell-shaped sac, containing the sharp-pointed, four-edged, calcareous, irritating dart, is turned inside out, like the common genital sac, before this remarkable instrument is prepared for action. With these little laminated stiliform portions of calcareous matter, moulded into a quadrangular periphery by the four sides of the containing sheath, the two snails engage in amorous contest as a prelude to their embraces, and when a portion of the instrument is broken off, which often remains fixed in the opponent's skin, it is renewed by the addition of new laminæ to the fixed base of this delicate spine. The dart is wanting in the naked slugs, though as languid in all their movements as the snails.

The most elevated form of the genital apparatus met with in this class, though not the most complicated in the number of its parts, is that separate condition of the sexes presented by the great order of pectinibranchiate gasteropods, comprehending almost all the inhabitants of univalve, unilocular, spiral, or turbinated shells. In these, as in the higher classes of animals where the sexes are separate, we still see the closest analogy in the structure of the genital organs in all the individuals of the species, and that the sexual distinctions arise not from the formation of new or distinct organs in different individuals, but from the unequal development, and a change of function, of parts of the same apparatus common to both, from the great development of the organs of excitement in certain individuals constituting the male sex, and the great development of other parts of the same structure, relating more immediately to conception in those individuals which compose the female sex. In the pectinibranchia we commonly find the long, tapering, lobed testicle of the male, placed on the right side of the posterior, narrow, and spirally-twisted portion of the body which fills the closed extremity of the shell. It accompanies the lengthened liver in its course through this tapering posterior part of the cone, and keeps the

right side of that organ through the spiral turns. The vas deferens, narrow and convoluted at its commencement, like an epididymis, keeps the same side of the body, and becomes wide and tortuous to the region of the anus, on the right and anterior part of the cavity of the mantle. At this part it enters the long, muscular, and erectile organ of excitement, along the inner surface of which it passes, still wide, and convoluted in a zig-zag manner, to the small, tubular, conical organ of intromission, placed at the distal extremity.

The ovary of the female, like the testicle of the male, extends along the right side of the liver, through the small, tapering, spiral turns of the shell. The long and wide oviduct passes forwards on the right side, like the vas deferens of the male, and after dilating to form a large glandular sac, close to the rectum, it opens generally near to the anus, at a short distance behind that orifice, and near to the glandular foliated sac, largest in the female, which appears destined to form the tough capsule we commonly find covering the ova. In the common *purpura lapillus* these capsules have the form, and colour, and size, of grains of corn, and are attached separately, by a little spreading peduncle, in thousands to the surface of rocks, near the shores of the sea. The horny capsules, when first deposited, are soft and white, but they soon become firm and yellow, and each contains about fifty-five embryos, which escape from the capsule when mature, by the operculum at the free extremity of the capsule dropping off. There are about twenty young developed in each capsule of the *buccinum undatum*, which capsules have the form and size of split peas, and are aggregated together in large balls, containing three or four hundred capsules. Many genera, however, as the *trochus* and *nerita*, deposit their ova in small gelatinous masses, which are attached to the surface of marine plants, without having an exterior capsule to protect them, and we see ova enveloped in the same naked gelatinous transparent mass in the fresh-water pulmonated gasteropods, as the *limnea*, and in most of the naked marine species, as the *doris*, *eolis*, and *tritonia*. The young embryos are provided with double circles of vibratile cilia, which are seen in rapid action, through the transparent sides of the ova, and with these organs they are able to swim freely through the sea when they first escape from the ova; this is observed both in the pectinibranchiate and nudibranchiate gasteropods, and in species of other orders.

The generative organs of the pteropods are constructed on the simplest plan of those presented by the nudibranchiate gasteropods, to which these animals are so closely allied in their living habits. At the bottom or posterior part of the closed sac formed by the mantle in the *clio borealis*, is found the lobed ovary, with a short and narrow oviduct which opens into a wide and long convoluted glandular canal, considered generally as a testicle. This glandular enlarged portion of the oviduct terminates in a small round sac, which opens under the branchial expanded membrane on the right side of the body, where the organ of excitement is placed. In the *hyalea* the organs of generation are nearly the same as in the *clio* in their structure, but not in their forms. The ovary of the *hyalea* occupies the whole of the right side of the abdominal cavity, and the testicle, as it is termed, is nearly as large, and of a lengthened and lobed form. The short ducts of these two separate glands open into a more wide and common canal, and the short curved organ of excitement, lying below the œsophagus, opens at a little distance from the mouth. The structure and form of these organs is nearly the same in the *pneumodermon*, where the common canal of the ovary and testicle, or accessory gland, opens a little anterior to the anus, in a groove extending forwards on the right side of the body. So that we observe a considerable resemblance in these female organs of the pteropods to those of the *tritoniæ*, *scylleæ*, and other naked gasteropods carried by the floating fuci through the ocean.

In the cephalopods, as in the fishes above them in the scale, the sexes are distinct, and placed on different individuals, but the females appear to be much more numerous than the males. In fifty *argonautæ* dissected by CHIAJE, not one was male, and in the more common forms of naked cephalopods the proportions of the males to the females are regarded as one to twenty. The females appear also, as in fishes and amphibia, to be larger than the males of the same species. The ovary, single like the testicle of the male, occupies the posterior closed extremity of the abdominal sac, and consists of a mass of minute, round, highly vascular vesicles, connected together by ramified peduncles. This ramified cluster of oviferous bodies is surrounded with a minutely striated and glandular capsule to the anterior part of which it is suspended. The oviduct, arising single from this capsule, soon bifurcates, and each division of the duct passes through a pyriform laminated glandular organ, like those of the two oviducts of rays and sharks. They open in the interior of the sac of the mantle, on each side of the body, at some distance behind the wide base of the funnel.

The testicle occupies in the male the same place as the ovary of the female, and consists of a congeries of ramified small cæcal tubes, contained, like the analogous organ of the female, in a glandular striated capsule, from which the thin, narrow, convoluted, spermatic vessel commences. The vas deferens, passing to the left side of the body, enters a more wide and tortuous canal, which receives the orifice of a small round sac, as in most of the gasteropods, before it terminates in the short tubular penis. In this small round sac are contained the remarkable spiral filaments of NEEDHAM. The male organ of excitement, placed on the left side, extends farther forwards towards the base of the funnel than the oviducts of the female. The products of the generative organs in both sexes appear to be conveyed outwards through the funnel. The ova of the *loligo* pass out enveloped in short, thick, white, gelatinous chords attached to each other in a mass, and are fixed to marine plants or other submarine bodies. Those of the *sepia* pass out attached to each other by gelatinous peduncles, like a cluster of black grapes, and are attached, as in the other genera, and as in most of the inferior molluscous classes, to the surface of submarine bodies, where they are left to pass through the succeeding stages of their development. The instincts of these highest of the molluscous, and of all the invertebrated animals, appear not to extend beyond the deposition and impregnation of their ova, and the fixed condition of some of the minute existing foraminiferous cephalopods, by means of their shell, or by some part of their body, has led to the belief that their genital system must be entirely female, like that of the lowest acephalous mollusca.

LECTURE LVIII.

ON THE GENERATIVE SYSTEM OF FISHES AND AMPHIBIA.

THE sexual differences of the genital organs already established as a normal character in the cephalopods, is preserved throughout all the classes of vertebrated animals, but we still find all the individuals of each species of these highest classes, commencing their development in both sexes, with the same form of genital apparatus, and that form is female, like all the lowest tribes of invertebrated animals in their adult state. In all the animals we have hitherto examined, the male and the female organs are alike closed at their upper extremities, and open only by their lower external orifices, so that the ovary and the testicle have been hitherto continuous with, and parts of, the oviduct and the vas deferens, and the same character continues in the male organs upwards to man himself. The secreting glandular part of the ovary now, however, becomes distinct from the oviduct, and preserves the isolated character of a separate and closed ovary, from the cartilaginous fishes, upwards, through all the higher vertebrata; so that having no duct or outlet, the secretions of the component cæca of the ovary must burst their capsule to escape into the detached oviduct. The organs of generation in the vertebrated classes are always double and symmetrical in both sexes at an early period of existence, but their development proceeds unequally on the two sides of the body in the females of birds and monotrema,—the last remnant of their unsymmetrical development, so common in the invertebrated, and especially in the molluscous tribes. The similarity of these organs in the two sexes is most obvious at the earliest period of their development in the highest classes, and throughout their whole career in the lowest. It is probably from this close resemblance in the structure and form of the genital organs of the two sexes, that many species of fishes have been regarded as consisting entirely of females. The lophobranchiate fishes have been regarded by PALLAS and by MECKEL, as all females, like the lowest cyclobranchiate gasteropods and the acephalous tribes beneath them in the scale. The lampreys also have been considered as all females, and several fishes, from the different condition presented by the different parts of the ovaries, have been supposed to possess double male and female organs in the same individuals. CAVOLINI maintained that the labrus channa and the sea perch possess, in the same individuals, two ovaries and two testicles, and this from observing parts of the ovaries undeveloped, and somewhat resembling the ordinary condition of testicles, as subsequently shown by RUDOLPHI.

Fishes, so imperfect, as vertebrated animals, in all their more important systems, still present the generative organs so near to their embryo state of simplicity, that they not only most closely resemble each other in the structure and form of those organs in the two sexes, but also in all the rest of their body the sexes most closely resemble each other, like the higher classes of animals in their young state, before the sexual organs begin to exert their influence over the whole body, and like the invertebrated lowest

tribes, where no sexual distinctions exist. It is chiefly in the higher reptile forms of the fishes, in the rays and the sharks, that we observe a marked difference in the sexes, and this affects both their internal and their external parts, and, to a small degree, the volume of the whole body. The females appear to be generally larger than the males in the fishes, as in the amphibia, and the males surpass them in the beauty and variety of their colours. Fishes, like the inferior tribes of animals, are more subjected to the influence of the seasons in their generative function, and have fewer instincts with relation to their future progeny, than the higher vertebrated classes. This is most marked in the osseous fishes, where the generative organs are most simple in their structure, and the sexes the most similar, where the impregnation of the ova most frequently takes place after their separation from the body of the female, and where, consequently, there is least intercourse between the sexes.

The ovaries of the osseous fishes consist generally of two long membranous sacs extending upwards from the posterior part of the anal opening; they communicate at their lower end, and open by a single orifice into the common cloacal part of the intestine. They extend forwards along the sides of the vertebral column, below the kidneys and above the rectum and alimentary canal; so that they have the rectum in front and the urinary organs behind them,—a position different from that which they occupy in the mammalia. They resemble those of the human embryo when first detached from the corpora Wolffiana. These great ovarial sacs are suspended by a duplicature of the peritoneum, and are generally distinguished by great vascularity at their dorsal or posterior portion. This highly vascular posterior part, extending along both divisions of this great bifurcated ovarial sac, is thicker than the anterior parietes, and has a cellular or cancellated internal structure. The ova are developed in the cells of this posterior portion, and when mature, they burst the cells, and escape into the anterior part, which forms an undivided continuous sac, opening below into the anus. The posterior parietes of these two sacs form, therefore, the secreting ovaries, and the anterior or inferior hollow portions form the two oviducts, in which the ova are enveloped, and connected by a viscid secretion, preparatory to their being expelled in a connected mass. While the oviducts, as we may term these anterior membranous portions of the ovaries, are gradually filling with ova which have escaped from the anterior layers of cells, other ova are advancing to maturity in cells immediately behind them, and thus the two great sacs become filled with tens of thousands of ova, all arrived at the same degree of development. I have found these two sacs in the *lophius piscatorius*, when filled with ova, to have a length of nine feet, with a diameter of five inches, and the contained ova about half a line in diameter, so that there may have been some millions of ova distending these enormous sacs, and filling the whole cavity of the abdomen. In some of the osseous fishes, as the blennies, where the ova are impregnated internally, the ova remain suspended by their peduncle, and undergo the same process of development within the two great sacs, which they undergo in the oviparous species when they are detached from the oviducts and left to develop in the water. These ovaries present a lobed appearance, like the kidneys of a serpent, in the lampreys, and in the eels and trouts, and the ova have been thought to burst through the parietes of these lobes into the abdominal cavity, and to escape by the two lateral openings near the anus, no other outlet or oviduct being perceptible. Sometimes the ovary of one side of the body only is developed, and sometimes the one ovary has the appearance of a testicle, while that of the opposite side has the ordinary appearance and structure of an ovary. Cuvier observed the posterior part of the ovaries of the serranus or sea perch to have very much the structure and appearance of the ordinary testicles, while they preserved the natural ovarial structure in their other parts.

In the osseous fishes the testicles, or milts, have the same situation, and nearly the same form, as the ovaries in the other sex, and they resemble in form those of the human embryo when first formed with the kidneys from the deciduous corpora Wolffiana. They consist of two long glandular sacs, extending forwards below the sides of the vertebral column, suspended by their peritoneal covering, communicating with each other behind the rectum, like the ovaries, and opening by a single orifice behind the anus. Their thick vascular secreting parietes pour into their interior a turbid white impregnating fluid, abounding with myriads of animalcules, and which distends these sacs like the ovaries at the breeding season. Lewenhoek calculated in the seminal fluid of a single fish, thirty times as many animalcules as there are of the human race on the surface of the earth. The testicles, like the ovaria, open before the urinary passage, sometimes by a simple round orifice, and sometimes by a prominent papilla, which resembles the open, grooved penis of reptiles.

This rudimentary male organ is seen in the blennies and other viviparous species, and serves as an organ of intromission to impregnate internally the ova of the female. The same grooved papilla is seen at the opening of the oviducts in the females of these species, and represents the clitoris of higher classes. The clitoris and the penis are also developed at the same period of the human embryo. In most of the osseous fishes, as in the amphibia above them, the ova are impregnated by the male after they have been discharged from the body, which shows that their whole development in the body of the female, and their discharge from the oviducts, is in no way dependent on the influence of the male. This high position of the testicles in the cavity of the abdomen, not only corresponds with the position of the ovaries in the opposite sex, and with the permanent situation of the testicles in all the higher oviparous classes, but also with the place which these organs occupy in the embryo state of all the higher viviparous quadrupeds and man.

As the ova in the osseous fishes, without internal impregnation, are all developed nearly at the same time, so we find them discharged from the body almost simultaneously in a mass; but in the viviparous species, as in almost all other animals where the impregnation takes place internally, the ova are found in very different stages of development in the ovaries at the same time, and the young are seen to pass out in succession from the oviduct as the ova are hatched within that cavity. The young often attain to a considerable size, before bursting, by the powerful action of their tails, the exterior membrane of the ovum, where they were enclosed along with the vitellus, which communicates by a narrow opening with the cavity of the small intestine, as in higher animals. The instincts of the osseous fishes relating to generation, extend almost exclusively to the deposition and impregnation of the ova, as in the amphibia and the inferior invertebrated tribes. In order to spawn in places suited for the aeration and development and safety of the ova and the young, they betake themselves at that season, often in vast shoals, to a different climate, or to the shallow shores of the sea, or ascend estuaries and overleap cataracts, followed by the males, to impregnate the ova after they are discharged from the females. This function performed, they return to their wonted haunts, and leave to nature the development and rearing of the embryos and young, attached by their glutinous exterior to rocks or plants. The ova discharged from the synguathus are received from the anus into a long external abdominal pouch, formed by two lateral folds of the skin, in which they are hatched, like the ova attached to the false feet under the post-abdomen of a lobster, or like the young in the abdominal pouch of a marsupial quadruped, or in the dorsal cells of a *pipa*. The whole yolk of the osseous fishes is swallowed into the abdominal cavity by the extension and gradual contraction of the abdominal parietes over its exterior, as in higher classes. The minute scales are already seen developed on this cutaneous covering of the yolk, distant from each other. From the greater risk of complete impregnation where that takes place externally, and where there are such myriads of ova, we find the cicatricula, or the impregnable, part of the ovum, to extend here, as in the similarly circumstanced amphibious animals, nearly over half the surface of the ovum. The outer layer of the covering of the yolk is continuous with the skin, and the inner layer with the intestine, and there is often seen in the abdomen of the adult sharks a sac on the intestine left by the vitellus.

In the highest cartilaginous fishes—the rays and the sharks—we observe a more complex structure of the genital organs than in the osseous fishes, and one which is interesting, from the circumstance that we there witness the commencement of that distinct and unconnected form of the most essential female parts, the ovaries and the oviducts, which continues upwards to man. The form of the ovaries in the osseous fishes is a simple bifurcated sac, with thin membranous parietes, and a cellular internal structure at their dorsal part, and their proper secreting ovary is only the cellular portion of the parietes next to the vertebral column. But in these cartilaginous fishes, as in all higher animals, the ovary is a distinct organ from the oviduct, and quite unconnected with it in the cavity of the abdomen. This results from the complete concentration of all the secreting part of the long ovarium of the osseous fishes, at the upper part of the ovary, and a complete separation of that secreting upper portion from the duct destined to convey its products. Thus we arrive at the origin of the separate ovarium and oviducts, and we begin a series of animals where the female generative parts, the oviducts, are open both above and below, which we have not yet seen from the monad upwards; they were closed in the female as in the male. We are coming to forms of animals where there is a more marked difference in the adult sexual parts of the individuals of the same species, than in the inferior tribes, when

they were nearest to their origin, and most like their embryo state in higher animals. So it is in the human body, when the genital and urinary glands are beginning to be formed from the primitive and deciduous corpora Wolffiana. At the earliest period of development the two sexes are precisely alike, and formed according to the female type—all females, like the lowest animals; at a later period a difference becomes perceptible, and by the great development of the organ of *conception* in the one, and of *excitement* in the other, the most marked difference is established, which at length affects the whole structure and form of the body. This early identity of the sexes is also curiously connected with the theory of monstrosities, which so often present themselves in the forms of these parts, especially in the lowest vertebrated classes, where they are naturally most like to each other in the two sexes, and consequently most easily changed into each other. You thus see, in the inferior osseous fishes, that sometimes one half of the body is male and the other is female; that one half of an ovarium is in form of a testicle, and that the other half of it below is like an ovary, resulting only from a slight difference in the kind of organization of the same continuous sac by which the one is probably, but not certainly, enabled to secrete the impregnating fluid peculiar to the male condition of these organs, and the other to secrete only the little sacs of nutritious matter which constitute the ova of female parts. It is more easy to change one form into another, where the differences between them are slight, as in this case of the genital organs of osseous fishes. Where the differences are more strongly marked, earlier commenced, and more influential, there we find, as in all the highest animals, and especially in birds, where the genitals of the two sexes are very dissimilar, less of such monstrosities. In the rays and sharks, those two isolated glandular organs for secreting the ova—the ovaries—are situate at the upper and most anterior part of the cavity of the abdomen, immediately below, and at the sides of, the vertebral column, in contact with the fold of the peritoneum, which assists in separating the cavity of the abdomen from the cavity containing the heart. Those ovaries discharge their ova, in slow succession, as in birds, into the cavity of the oviducts, to receive additional coverings when they are matured sufficiently for that last condition. The two oviducts are here wide, convoluted, and of a lengthened form, connected behind by a fold of the peritoneum, like a mesentery, and open above by a broad infundibulum, very near to the anterior extremity of the cavity of the abdomen, close to the ovaries; below, they meet, and unite in a uterine sac situate behind the rectum. The yolks, of great size, escaping from these large botryoidal ovaries, are seized by those wide infundibula and thick glandular oviducts, and conveyed slowly through the canal formed by their glandular parietes, where they are surrounded in the upper part of their course by the transudation of a thin, transparent, whitish, albuminous matter, like that surrounding the yolk of a bird's egg. The outer membrane of the ovum in all fishes is the chorion; the inner membrane is the yolk-bag, as in higher classes. In their course downwards through those oviducts, they encounter two large kidney-shaped glandular organs, like those we already have seen on the oviducts of the cephalopods, one upon each oviduct.

As the ovum passes through this glandular organ, it becomes enveloped with a large, compressed, tough, horny, elastic capsule, which has a quadrangular form, and, at its four angles, is prolonged generally into long convoluted filaments of the same horny matter, formed by the two sides of the gland, and it is sometimes covered with elevated, thin, transverse, parallel laminæ. Thus, covered with its horny exterior capsule, this impregnated ovum is now provided with the means of gradually distending the lower part of the oviduct, by the projecting anterior or descending angles of those horny capsules, which are thin and elastic; by their elasticity, and their extending forwards through the oviduct, they have a tendency to open that delicate passage, as they pass along it, with their dense covering and sharp-cutting edges. The long, convoluted, glutinous filaments extending from the four angles of this compressed ovum, serve to attach these ova to marine plants, rocks, and other substances, or to keep them suspended from the anus for a time, where they are held secure till they are hatched, and the young escapes from one end of the ovum, which is easily opened. Frequently they are retained in the cavity of this last-dilated lower portion of the united oviducts so long, that the capsule opens at one end by the separation of its simply contiguous edges, the young escapes, and the capsules themselves are discharged after the young, thus presenting an ovo-viviparous mode of generation, as in many reptiles. We observe that the young, while retained in those capsules, arrive at a high degree of development, and present the yolk-bag opening, by a narrow umbilical passage, almost as in birds and mammalia, into the cavity of the intestine, and hanging externally from that umbilical aper-

ture. It has here, in this young ray, not been swallowed up by the continuous parietes of the abdomen, extending over the whole, as in the osseous fishes, but opens through an umbilical aperture into the small intestine, and the long tufts of respiratory filaments are still seen hanging from the exterior of the gill-openings.

In the male we observe in those tadpole-like, plagiostome, cartilaginous fishes, a corresponding high development of the genital apparatus, and a considerable difference in the external form of the sexes. The short, lobed testicles are placed high in the cavity of the abdomen, like the ovaries of the female, and are loosely attached, like them, to the sides of the vertebral column, by their peritoneal covering. Their lobes are composed of numerous smaller lobuli, each of which consists of innumerable, very short, and minute tubuli-semeniferi. The wide vas deferens, which comes from each testicle, passes forwards, then backwards, in the most convoluted manner, forming a long and large epididymis. The convolutions are most numerous and close at the upper or anterior portion of this long epididymis, and they become less as the duct enlarges, and proceeds backwards to form a dilated part, like a vesicula seminalis. The two seminal ducts, continuing downwards or backwards in the horizontal position of the body, from these small vesiculæ, end both in the same prominent conical papilla, which serves as an organ of intromission to impregnate the ova of the female internally. A part of the foot, or ventral fin, on each side of the male, is remarkably developed in size and in complexness of internal structure, to serve as an organ of prehension, to seize and retain, and probably to excite, the female during copulation, which is probably effected by the rays, which have no air-bag, in a recumbent position, on the sands at the bottom, where they reside, as well as floating vertically in the water. This prehensile organ of the male is sometimes in form much resembling the foot of a bird, and capable of being extended from a sheath in which it lies concealed. The testicles here occupy the place of the ovaries, the vasa deferentia that of the oviducts, and the vesiculæ that of the uterine enlargement of the female. The testes, like the ovaries and the kidneys, are developed from the corpora Wolffiana. In the carcharias, where the ovum is commonly hatched within the oviducts, or in their uterine sac, the covering of the ovum is thin and membranous, but provided with the usual long convoluted filaments, formed, with the capsule of the ovum, in the large reniform glands of the oviducts. The external tunic of the yolk is continuous with the skin and abdominal parietes of the embryo, and is nourished by their vessels, but the inner membrane of this yolk-bag, continuous with the membranes of the intestine, receives its arteries from the cæliac, and transmits its venous blood to the venæ portæ; consequently there is no allantois nor umbilical vessels. The surface of the diminished soft chorion of the yolk-bag was found by Cuvier to adhere to the inner surface of the uterine sac in the carcharias arrived at the full time, as firmly as by a placenta, and by a highly vascular peduncle. Thus we observe in the plagiostome cartilaginous fishes, the rays and the sharks, the most complicated form of all the genital apparatus met with in this lowest of the vertebrated classes, and a form of the generative function most nearly approaching to that of the higher oviparous and even viviparous vertebrata.

The sexual distinctions are less equivocally established in all the amphibious animals than we often find them in fishes, and these marked differences in the generative organs of the two sexes are here accompanied by more obvious distinctive characters in the general form of the body. We often observe in the amphibia the external sexual distinctions increased at the breeding season, when the internal generative organs are in most activity. The longitudinal dorsal serrated crest of the male tritons, and the hands of many of the male frogs, undergo a considerable change of size and form, corresponding with the periodical changes in the generative organs within, and we observe the same kind of changes produced periodically in the external dorsal cells of the female *pipa*. Sometimes the whole anterior extremities of the male frogs enlarge at the breeding season, and the external colours become more lively, as in the scales of the finny tribes in the season of procreation. The males are commonly smaller animals than the females in this class, as we see also in many of the fishes and reptiles.

The generative organs of the amphibia are symmetrically developed on the two sides of the body in both sexes, and, like fishes, they are remarkable for their fertility. The two ovaries of the frogs and toads are situated in the anterior and dorsal part of the cavity of the abdomen, connected, by a broad and convoluted duplicature of the peritoneum, to the sides of the vertebral column, behind the heart. This covering expands to form a large continuous round sac during the great development of the ova. The two long, tubular, glandular, convoluted, and wide oviducts, with thick, white, secreting pa-

rietes, have their two superior openings near to those of the ovaries, at the sides of the heart. The ova, seized by the wide infundibula of the oviducts, imbibe through their chorion a transparent gelatinous secretion as they pass through their canals, which envelops the whole yolk, and which swells to a great size by absorbing water when the ova are discharged from the body into that medium. The oviducts dilate at their cloacal termination, as in many cartilaginous fishes, and from this uterine sac, formed by the union of the enlarged terminations of the oviducts, the ova are conveyed out through the cloaca, to be impregnated by the male fluid, effused over them as they escape from the anus. The ovaries here are attached farther back in the abdominal cavity than the anterior free proximal terminations of the oviducts, and farther back than in the cartilaginous fishes, so that when they are distended with ova they fill the whole of the middle and dorsal part of the abdominal cavity, and the wide, convoluted, glandular oviducts surround their sides, from the heart to the anus. The ova, in the plicated and cellular ovaria, advance equally in the march of their development, and appear, as in the osseous oviparous fishes, without internal impregnation, like simple sacs, filled with black globules of the same size, when mature for the oviducts. The want or imperfect state of the ribs allows them space to distend the abdominal parietes, and to develop in thousands, as we see in the lowest fishes, which, like them, have no internal impregnation. The ovaries here resemble in form the long, convoluted, membraniform ovaries of chelonia, but the ova of chelonia, like those of birds and of viviparous fishes, are found in very different stages of development, from their internal mode of impregnation.

The male organs of the frogs and toads, though differing in form and function from the female parts, have still a considerable analogy to them in internal structure and position, as we see in inferior classes of animals, and in the embryos of higher, and they originate from the same deciduous glands. The two white soft reniform testicles, consisting of minute follicles, or short tubuli semeniferi, are attached, like the ovaries, to the sides of the vertebral column, behind the heart and liver, at the same place with the long adipose lobes; and the convoluted vasa deferentia after forming a small epididymis, which is perceptible even in the proteus, pass down more straight, along with the two ureters, through the pelvic region, and dilate into two small vesiculæ seminales before they open into the cloaca. The testicles, and the whole of the genital parts of the male, swell at the breeding season, like those of the female; and the male frogs, which are smaller than the females, leap upon their back, and, embracing their abdomen firmly with their enlarged tuberculated wrists, remain in that situation for several weeks. The females betake themselves with their burden to the water, where, from the density of that element, the weight they support is diminished, and where they are excited to the expulsion of the ova, and assisted in that process, by the pressure of the adhering and embracing arms of the male. As the ova are expelled, they are impregnated externally by the effusion of the seminal fluid from the cloaca of the male, without the aid of an organ of intromission, as in the lowest oviparous fishes. The exterior membrane of the ovum quickly imbibes water, which swells the outer albuminous portion enveloping the yolk, to more than double its original size, and thus masses of ova are produced by the same frog, which many times exceed the size of its whole body. These ova adhere together by their glutinous surfaces, sometimes in the form of long cords, or bands of ova, and sometimes in large, round, or lobed masses, adhering to stones, or other substances, under the surface of the water. They are in great part consumed by birds and fishes and other tribes of animals; and the development of those which escape, and the bursting of the ovum by the muscular tail of the black uncoiled embryo tadpole, very much resemble the same phenomena in the ova of osseous fishes.

The developed condition of the testes and ovaries seen in the *axolotls*, the *proteus*, and other amphibia with permanent gills, shows that these are not larvæ, but the adult conditions of inferior tribes. In the *tritons* the ova are impregnated within the oviducts, and pass out connected together in long cords, where the young embryos require about fifteen days before they are ready to escape from the ova, and they retain their branchiæ to a late period of their development.

The male of the land *salamanders* possesses a small organ of intromission, like the sharks and the rays, and impregnates by copulation. The ova are hatched in the oviducts of the females, and the young are deposited in pools of water, already formed, like the tadpoles of tritons, with a compressed vertical tail, and with free external branchiæ. The tail here undergoes only a partial metamorphosis in losing its thin vertical margins, and becoming round and short like that of the adult. The anterior extremities develop before the posterior in these inhabitants of damp and marshy grounds, as in most of the higher

animals; and, contrary to what we observe in frogs, where the posterior extremities are first formed, are permanently large, for leaping and swimming, through the whole of life. The male of the large Surinam toad, *bufo dorsiger*, spreads the newly-discharged ova over the rough back of the female, and there impregnates them, exposed upon the surface and adhering. The female betakes herself to the water, the ova swell, and the skin of the back, at first without cavities, extends over them in the form of open cells, where not only the ova are hatched, but where the young remain till they have passed through their metamorphosis, lost their gills, acquired feet, and are ready to accompany their parent from the water to her wonted dungeons and solitary haunts. The male of the little *bufo obstetricans* assists in extracting the large ova from its mate, impregnates them, and fixes them in clusters by glutinous filaments to its own thighs. It thus retains the developing ova till near the period of their hatching, when it betakes itself to the water; the ova burst, the tadpoles escape into the water, and the male parent, cleared of its burden, seeks its accustomed rocky retreats. Thus, we observe, that in proportion as the organs of generation, and the whole structure of animals, become more complicated, the instincts extend beyond the mere deposition and impregnation of the ova, and become gradually more extensively and mysteriously connected with the future wants and conditions of the young.

LECTURE LIX.

ON THE GENERATIVE SYSTEM OF REPTILES AND BIRDS.

As all the different species of animals form the component parts of one great and connected system, they are equally important in the economy of nature, and means are adopted to preserve their existence, not according to their supposed utility, or imagined pre-eminence, but according to the dangers which threaten the extinction of their race. The lowest classes of animals, exposed incessantly to perils which they can neither perceive nor avert, and even the fishes and amphibia, the easy prey of all the higher predaceous tribes, pour forth their ill-fated progenies in multitudes, like the sands of the sea, and they are destroyed in proportionate myriads before they arrive at maturity. But as the means of foreseeing and averting danger increase, by the high development of the general structure and of all the organs of relation, the number of such protected progeny is diminished, and the young are retained to a later period of their development in connexion with the body of the parent. The internal mode of impregnation, and, consequently, the internal development of the embryo, to a variable extent, becomes a normal character, from the ophidian reptiles through all the higher orders of vertebrata. By the gradual development and ascendancy of the organs of excitement, and the consequent increased connexion of pleasure with the generative function, it becomes more subject to the will and feelings of animals, less regulated by the seasons, less influential in the economy, and more precise and limited in its results. The male fluid is no longer thrown indiscriminately over myriads of ova already discharged and detached from the body of the female, but is conveyed, with great precision, by the activity of the villous surface of the oviducts, to excite a limited number of ova, and commence the development of the young while yet within the body of the parent. Purkinje and Valentin say, that they have seen vibratile cilia in rapid action on the lining mucous membrane of the oviducts and fallopian tubes of reptiles, birds, and mammalia, and also on the mucous lining of the lungs, for half an hour after death, by viewing the detached membrane in water under the microscope.

Notwithstanding the imperfect means of progressive motion and of prehension possessed by the ophidian reptiles, their sexual organs, which are double and symmetrical, are placed on different individuals, their impregnation takes place internally, and their organs of excitement are large and often double. Like most of the other viscera of their long cylindrical trunk, the internal organs of generation present a lengthened form in both sexes. The two long, white, lobed ovaries of the female are situated before the two lengthened kidneys, on each side of the spine, and exhibit the ova, like those of a bird, in very different stages of growth, and of various sizes. The two long, wide oviducts, open and dilated at their commencement near the ovaries, pass down separately, accompanied by the ureter of the same side, to the back part of the cloacal termination of the intestine. The ova, of variable number, generally of an oval form, equally broad at both ends, and covered with a tough strong membrane, are seen at the breeding season in equal numbers, equally developed, and placed alternately in the two opposite oviducts; they thus occupy less breadth within the body, and

pass out from the oviducts one by one alternately, but generally connected together in long chords by a glutinous matter formed in the oviducts. The embryos arrive at very different degrees of development within the oviducts, and are often hatched in that situation, as we have already seen in some of the amphibia and in many fishes and inferior tribes of invertebrata. The ova are commonly deposited on the ground, under bushes, or long grass, or stones, or in the cavities of decayed trees, where they are soon hatched, and the rearing of the young is left to nature, they having already attained a high degree of development before they burst the ovum. It has been observed by GEOFFROY that the common snakes by being kept long from water are made to retain their ova for a longer time in the oviducts, and until they are hatched, the same animals being thus oviparous or viviparous at the will of the experimenter. In the vipers the ova are generally retained within the oviducts till the young are developed and have escaped from their coverings. In a boa constrictor of ten feet in length the oviducts are about four feet long. The common *anguis fragilis* has, after long confinement, deposited before me twelve ova in the space of twenty minutes; they contained perfectly-formed young, enveloped in a thin transparent amniotic membrane, which they burst by the uncoiling and the struggling motions of their tail in about a minute after they were discharged from the cloaca. They presented a remnant of the yolk-bag suspended from the umbilicus.

The sexual distinctions are but slightly marked by external characters in these worm-like ophidian reptiles, and their internal generative organs have the closest resemblance to each other in their permanent forms and in their situations in the two sexes. The long, lobed, white testicles of the male are situate, like the ovaries of the female, anterior to the kidneys on each side of the spine within the cavity of the abdomen, and the vasa deferentia, but slightly convoluted to form an epididymis, pass down wide and separate, along with the ureters, to open into the sides of the cloaca at the base of the organs of intromission. They appear, as the ovaries of the embryo, at first like two long white filaments extending along the inner sides of the deciduous false kidneys, or corpora Wolffiana, and as they develop, they become more thick, short and lobed, than the ovaries, which acquire a more lengthened, narrow, and equal form. The male organ, single in the cæcilia, as in salamanders, is generally double, and bifurcated, and covered with recurved stiff spines at its free extremity. It is double, and each with a bifurcated glans, in the *boæ* and *pythons*; and these organs of intromission or excitement are lodged in a long pelvic cavity posterior to the anus, protected above by the long curved and double transverse processes of the coccygeal vertebræ. The penes are most bifurcated in the rattle-snakes. They open into the cloaca, and protrude from that cavity in the act of impregnation. The male and female serpents dart their tongues, rub their necks and their glistening skins together, twine their bodies round each other, roll upon the ground, and bring their ani into contact, when about to copulate. The rattle-snakes and some other viviparous species are said to protect their young for some time after birth.

Although less lengthened in form, the male and female organs of the saurian reptiles agree in general structure and position with those of serpents. The two ovaries are situate, like the two testicles of the male, high in the cavity of the abdomen, anterior to the lengthened and permanently-lobed kidneys; and the two oviducts, like the two vasa deferentia, pass downwards or backwards between the kidneys, accompanied by the two ureters, to the cloacal part of the intestine. The ovaria present the ova in various stages of growth; and five or six are often seen in each oviduct in the lizards, passing down in a continuous row, of the same size and form, and covered with a tough external membrane. They are impregnated internally, but are hatched out of the body by the natural heat of the climates they inhabit. The convolutions of the vasa deferentia in the males, form a more distinct and compact epididymis than in serpents, and terminate near each other in the cloaca at the base of a double organ of intromission, the two distal extremities of which are covered with sharp recurved horny papillæ as in serpents. Some are viviparous, as the *seps*, which is almost in the condition of a serpent, from the smallness of its extremities and their distance from each other. The *iguana*, so common in the woods of South America, where it feeds on the leaves and the fruits of the trees, deposits its large eggs in the sands. They form esteemed articles of food, like the flesh of this reptile, and are observed to consist chiefly of the yolk, with very little exterior albuminous matter. In the males of the lacertine and iguanian and scincoid sauria, the organ of intromission is distinctly double throughout, as in most serpents, and the lower openings of the oviducts are at a corresponding distance from each other in the cloaca of the females.

The large concentrated ovaries of the crocodilian sauria are placed more posteriorly, near the kidneys, and the wide glandular convoluted oviducts pass forwards, then backwards, in their course from the ovaries to the sides of the cloaca. The clitoris appears in a rudimentary state, and near it, on each side, the two tubular papillæ, which lead from the cloaca into the cavity of the peritoneum. The ovaries appear often like two large clusters of minute white round ova. The testicles occupy the same position before the kidneys in the abdomen of the male as the ovaries in the female; and the vasa deferentia, after forming a distinct epididymis, pass backwards, wide and convoluted, to terminate in the back part of the cloaca at the base of a large grooved organ of intromission. This organ consists of an imperfectly divided corpus cavernosum, grooved below as in the tortoise, and capable of forming a tubular canal, by the meeting of its sides in a state of erection, when it projects from the cloaca and the anus. In a relaxed state it is concealed within the cloaca, like that of a tortoise or of an ostrich; and on each side of its base are seen projecting into the cavity of the cloaca the tubular papilla leading from the general peritoneal cavity of the abdomen. The ordinary divided form of the male organ in the sauria is least observed in this grooved organ of the crocodilian family in the alligators, the gavials, and the true crocodiles. In the *crocodilus rhombifer*, Weber observed two distinct male organs, as in lizards and serpents, and covered not with horny, but with solid earthy spines.

The alligator of Guiana, *alligator sclerops*, deposits about sixty eggs in the loose sand, covers them over with dried leaves or straw, and defends them courageously when attacked. The alligators are said to bellow like oxen when they meet for impregnation in spring. The eggs of the alligators have a tough, hard, and white calcareous covering, and the young, when hatched, escape immediately to the water to feed on worms, larvæ, and other small aquatic animals. The eggs are used as food in Carolina and other parts where these animals abound. The common crocodile of the Nile deposits eggs larger than those of a swan, and covered with a tough, thick, white, elastic shell, which becomes more dry and brittle at the period of hatching. They are deposited at three successive periods, with short intervals, and about twenty each time are laid upon the sands to be hatched by the heat of the sun in about twenty days, if not destroyed by the carnivorous ichneumons constantly in search of them. The male crocodiles of St. Domingo, *crocodilus acutus*, combat fiercely for the females, which are more rare, and impregnate lying on their sides in the water. The females dig a cavity in the sands with their feet and their muzzle, deposit about thirty eggs in strata, alternating with layers of sand, watch and assist the escape of the young, which are small, defend them from the voracity of the males, and, it is said, feed them for some months, as pigeons feed their young, from the crop.

In the chelonian reptiles the two long plicated ovaries suspended behind the liver, resemble in their lengthened form those we saw in most of the amphibia. But here the impregnation is effected internally, as in other reptiles, and the ova enclosed between the two folds of this glandular organ, are hurried on to very unequal stages of development, in order that they may pass in slow succession into the oviducts, to receive the influence of the male. The ovaries appear like folds of the mesentery clustered over with round yellow yolks of all sizes. They are equally developed on the two sides of the body, like all the other genital organs of both sexes in the chelonia and other reptiles. The oviducts are long, wide, tortuous tubes, thin, membranous, and plicated internally at their upper part, more thick, glandular, and villous, on their inner surface towards their cloacal termination, and suspended from the sides by a broad, loose duplication of the peritoneum. The ova or yolks, seized loose by the upper wide membranous extremity of the oviducts, imbibe in their course through part a considerable portion of transparent, thin, albuminous matter, which distends the outer tunic of the ovum, and envelops the round yellow yolk. Arrived at the lower portion of the long oviduct, the outer surface of the chorion of these distended and almost spherical ova becomes encrusted with a layer of white calcareous matter of variable thickness, and sometimes nearly as dense as in the eggs of a bird. We often find four or five ova in each oviduct, already completely enveloped in their calcareous shell, and occupying a great portion of that canal. Thus enclosed in their tough calcareous covering, the eggs pass through the thick wide inferior uterine portions of the oviducts into the large cloacal termination of the intestine, by two contracted corrugated openings, and at each side of the cloaca there is generally a wide recess, more or less deep, into which ova may be received, till it be convenient to pass them on through the anus. The clitoris is here developed as in some of the sauria and the struthious birds, and occupies the same situation in the cloaca of the female as the

penis in that of the male. The two peritoneal openings seen in the cloaca of the crocodilian reptiles, and near the anus of most fishes, here pass through the interior and terminate at the apex or glans of the clitoris.

The testicles, highly vascular, like the ovaries, and consisting of numerous glandular cæca, or tortuous seminiferous tubuli, as in higher animals, form two reniform compact organs, below or in front of the lobed kidneys, and send out a wide, convoluted vas deferens, composed of the united trunks of the small tortuous cæca. This convoluted duct of the testicle forms a lengthened epididymis on its inner side, and then passes downwards, wide and less convoluted, along with the ureter of the same side, to terminate in the back part of the cloaca, at the base of a large and grooved penis. The penis, when present in animals, is generally large in proportion to the imperfect means which the sexes have of seizing or approaching each other in the act of impregnation, as we see in serpents, chelonia, cetacea, and other animals where this organ is disproportionately developed when compared with the other parts of their genital system. This large male organ, terminated by a dilated glans, and lodged in the prepucial cavity of the cloaca, is composed of a double corpus cavernosum, separated behind into two diverging crura, which pass down to receive attachment and support from the ossa ischii. Their inferior median groove forms a canal for the seminal fluid, by the meeting of its edges in the erected state; but there is yet no corpus spongiosum, for there is no urethra to pass through this imperfectly-formed embryo state of the organ of excitement. You perceive, from the simple form of this large organ in the tortoises, that the great outward bulk of an organ in the animal frame does not necessarily imply a high degree of development and elaboration of its internal structure. The two canals from the cavity of the peritoneum here, as in the females, pass through the corpora cavernosa, to terminate at the end of the glans, and not at the base of the male organ, as we saw them terminate in the crocodilian reptiles. The genital openings in the cloaca of both sexes are here interposed between the ends of the ureters and the urinary bladder, as in monotrema and other animals, where the parts retain this condition of development. The land tortoises dig a hole in the ground to receive their eggs, and leave their protection to their shelly covering, and their hatching to the elements. The large turtles of the deep, visit the desert shores by night, and deposit their eggs in excavated holes in some safe retreat, or upon the sands, beyond the reach of the tide. The eggs are deposited in great numbers, at intervals, in the same cavity, and the newly-hatched young, with their yet soft covering and thin soft bones, make speedily for the water, like the young crocodiles and alligators. The yolk-bag was observed by TIEDEMANN in the young *emys* to enter the abdomen and the intestine through an opening in the sternum, through which also passed the large allantois continued from the bladder.

The birds, like the insects, are remarkable for the high development of all their organs of relation, and this is not less obvious in what concerns the existence of the species, than we have seen it formerly in all that relates to the maintenance of the individual. Their high intellectual development and complicated instincts are not limited to mere sexual gratification in this function, or the disburdening their light body of the load of ova that weighs it to the ground; they select a safe retreat, most artfully construct their nest, watch over the products of generation with parental care, provide for the difficulties and dangers which attend the helpless condition of the young, and thus, most intimately, though mysteriously, connect one generation with another in endless succession. Yet, the condition of the generative organs in this class, and the degree of development of the young within the body of the parent, are scarcely higher than in the lowest reptile which throws its load of ova into the water and heeds them no more. The internal female parts of the birds merely prepare a large supply of nutriment, and a large and safe domicile for the future embryo, which must pass through all the phases of its high development, externally to the body of the parent. The evolution and development of the numerous and complicated young within the oviducts being incompatible with the living habits of birds, and having no marsupium for their reception, which would be alike incompatible with their activity, they must press their heated body on the developing eggs, and these must have solidity to withstand the pressure of constant incubation, and brittleness to yield to the struggling embryo when ready to escape. The safe transmission of the large and brittle eggs of birds through the abdominal and pelvic cavities, requires that they should pass down singly and in slow succession, which, however, would be incompatible with the functions of two perfect ovaries and two pervious oviducts in this class; and hence the necessity for that remarkable unsymmetrical development which we observe in the female genital

organs of birds. Yet all birds begin the development of their genital parts by having these organs not only similar on the two sides of the body, but identical in form in the two sexes. The sexual differences of the same parts gradually make their appearance in the different individuals which compose the species, and an unequal development is at length perceptible in the genital organs of the two sides of the body, those of the left side continuing to increase in magnitude and perfection, while those of the right side appear to stop, and to retrograde in the march of their development. This is, perhaps, dependent on the right descending aorta of reptiles being alone preserved in birds, as the left alone is preserved in mammalia, and we observe it often to affect, though to a less extent, the male as well as the female organs of this class. In a few birds the ovaries are seen equally developed on the two sides; often a rudiment of the right ovarium is seen beside the large ovary of the left side, and in others no trace of the right ovarium is perceptible. They lie under the prominent part of the sacrum, anterior to the first or largest lobes of the kidneys, and appear like a cluster of small, round, yellowish-white ova, of unequal sizes, and enveloped in a thin and highly vascular peritoneal covering, which ruptures when the ovum is mature, and forms a cicatrix when it has escaped into the oviduct. The oviduct of the right side is absorbed, or impervious at its upper part, corresponding thus with the atrophiated condition of the ovary of the same side; but it is often left in part vious, like a small cæcum, at its lower cloacal termination. The oviduct of the left side, when in activity, is long, wide, and convoluted, attached behind by a double fold of the peritoneum, loose like a mesentery, and has thick glandular parietes, plicated internally at its upper part, with longitudinal folds of the mucous coat, and more even and villous in the interior of it lower portion. It is thin, wide, and funnel-shaped at its upper ovarial extremity, without fimbriated margins, where it seizes the loose ova detached from the ovarium. The ova hang by only a small peduncle before they escape from their peritoneal covering, as you see in the wild swan. There are two ovaries, you observe, in this condor vulture, *cathartes gryphus*, a large left ovary, consisting almost entirely of pedunculated ova, and a much smaller right ovary, containing also some pedunculated ova, which, if detached, would have easily passed into the wide left oviduct with those of the left ovary. The upper portion of the oviduct below the infundibulum, is thin, soft, and membranous, narrower than the lower portion, and secretes the transparent colourless albuminous matter which is imbibed by the outer membrane of the ovum and envelops the yolk. Its internal plicated mucous coat passes insensibly into the even smooth villous surface of the inferior uterine or cloacal portion of the oviduct which secretes the external solid calcareous covering of the extra-vascular chorion of the egg. Both ends of the oviduct are smoother, however, than the intervening more glandular portions, and the inferior portion, which retains the entire egg with its shelly covering, is thicker, wider, and stronger, than the rest of this canal. This inferior uterine portion assumes also a longitudinally plicated internal surface in its collapsed state. It opens into the left side of the posterior or terminal part of the cloaca, exteriorly to the terminations of the ureters, by a contracted muscular orifice, capable of great dilatation. This posterior part of the cloaca, which receives the ureters and genital openings in both sexes in birds and reptiles, is analogous to the urethro-sexual canal of monotrema, and to the urethra of ordinary mammalia. The clitoris, when developed, as in the ostrich, and also the *bursa Fabricii*, when present, are situate more posteriorly, or externally, in a prepucial vestibule. This *bursa*, opening into the middle of the dorsal part of the cloaca, occurs in both sexes, is often a double sac, and is similarly situated to Cowper's glands in the mammalia.

The two soft white reniform testicles of the male occupy the same situation, anterior to the kidneys and close to each other, as the ovaries of the female, and they are more constantly equally developed and effective organs on both sides of the body than the corresponding organs of the other sex. They consist of numerous small tortuous tubuli or glandular cæca, converging from the periphery of the organs towards their interior or median margin, where they terminate in the spermatic vessel, and like the ovaries, they enlarge much at the breeding season, where that occurs periodically. The spermatic vessels form, by their numerous close convolutions, a small epididymis, extending along the inner margin of each testicle, and then pass down, more wide and less convoluted, near to each other, along the middle of the sacrum, to terminate, as in reptiles, and as the corresponding female passages of birds, in the middle of the dorsal part of the cloaca. They accompany the ureters, and open separately near them in the urethro-sexual or posterior part of the cloaca, where there is often a papilla, or a rudimentary open erectile penis, and

sometimes, as we see in the ostrich, a large grooved male organ, like that of a tortoise. This male organ, common in aquatic birds, is lodged, like the grooved clitoris sometimes seen in the females, in the terminal prepucial vestibule. When of different sizes, the left testicle is larger than the right, as in the ovaries of the female, thus showing that the unsymmetrical development of the genital organs, so important in the living economy of female birds, arises from some organic arrangement common to both sexes, though less influential and less important in the male.

With the generative organs of both sexes developed by nature at the pairing season, the male bird, like the male frog, leaps upon the back of the female, seizes her head with his beak, her pelvis with his feet, fans her with his wings, and pushes her tail to one side, and when the ani are juxta-posed, and the male fluid, or the male influence, is hurried on by the active lining of the oviduct, to impregnate at once numerous developed ova, which descend in slow succession through the open elastic pelvis, to be hatched externally by the tender care and heat of the parent or the parents. The seminal vessels are often dilated like two vesiculæ seminales before they terminate in the cloaca, and their two prominent terminal papillæ in the cloaca, correspond with the double penis, so common in serpents and lizards. The ovum of birds, like the Graafian vesicle of mammalia, is at first transparent and colourless in the young ovarium, then becomes white and turbid, and at length is a yellow yolk; it is gradually absorbed, and at length swallowed in, by the abdominal parietes of the developing chick, and we can often perceive on the small intestine of the newly hatched, and even the mature bird, a minute cæcal appendix left in the situation where the yolk-bag formerly opened into the alimentary canal. This I have also seen on the corresponding part of the small intestine in the human fœtus. The female bird can alone produce and discharge periodically its crops of ova, like the sexless coral its reproductive gemmules, but the development of the embryo requires the influence of the male. The abdominal situation of the testicles of birds still corresponds with their permanent position in the inferior vertebrated classes, and in the inferior orders of mammalia, and also with their embryo condition in all the higher species, and in man. The calcareous covering of the chorion in this class cuts off all connexion between the embryo and the parent, and necessitates an external development by incubation, as in a second uterus, where this porous crust becomes an organ of respiration to the developing fœtus, as the albumen evaporates and the yolk is absorbed. Thus we find in the birds, as in the reptiles, that the ovum seeks no new attachment, by means of its chorion, to the uterine system of the parent, after it is once severed from the ovary, and the two halves of the uterus, long and convoluted, like the two spermatic vessels of the male, still remain detached from each other, to their cloacal termination, like the oviducts of inferior animals, and the embryo uterus of all the higher animals and man.

LECTURE LX.

ON THE GENERATIVE SYSTEM OF MAMMALIA.

The generative organs of the mammalia present us with the highest condition of the most universal and important organic system possessed by living beings, that by which the existence of the species is prolonged on the earth beyond the limited period allotted to individuals, and this superiority is indicated by its numerous subdivisions, and the complicated character of all its parts, which are greatly diversified in form, structure, and situation, in the different tribes which compose this interesting class. The principal modifications of these organs in the mammalia are more obviously connected with differences in the general form of the body, or in the living conditions of the species, than in the lower classes of animals, and are in strict accordance with the unity of plan and the progressive march of development we have traced in this system from its lowest form. The sexual differences which distinguish the individuals of species are here more constant and great than in all the inferior classes, and the genital organs, which are double in both sexes, are for the most part equally developed on the two sides of the body. The bulk of the whole body, and especially the breadth of the anterior half of the trunk, is greater in the males than in the females, which are generally characterized by a greater development of the pelvic region, for the long-continued internal maintenance of the young, and the males are often distinguished by an increased growth of their external parts, as the hair, the horns, and the teeth.

The generative organs of the mammalia, like the general form and structure of the body, are at first identical in the two sexes, as we find them permanently retained in the lowest animals, and as they present themselves in the embryo state of all the higher classes. The ovaries here

remain small compared with those organs in inferior classes, and compared with the testicles of the male, and they contain at all times a comparatively small number of ova or vesicles. The ova are contained in a soft glandular and highly vascular texture, which is inclosed in a double tunic, and placed near the fimbriated extremity of each fallopian tube. The ovaries are unequally developed on the two sides of the body in the monotrema, that of the right side being sometimes, as in birds, scarcely discoverable, while the left appears like a large cluster of unequal-sized ova. The ova or ovules, in the ovarium of mammalia, as in birds, are most developed on the surface of the organ; they contain a transparent, colourless, oily, and albuminous fluid; they appear to escape by the orgasm of sexual excitement; they leave a yellow cicatrix or corpus luteum in the part of the ovary which they formerly occupied; they are seized by the wide fimbriated opening of the fallopian tubes, and they appear to be generally impregnated in these passages. The ovaries are the analogues of the testicles, and having no continuous internal ducts, with distinct openings, they secrete isolated globules of similar matter, or ovules, which, as foreign bodies, burst their coverings to escape, if not expelled by the convulsive orgasm of sexual union; they are situated where the testicles are first developed in all the mammalia, and where they permanently remain in many of the lower tribes; they are covered by the same tunics as the testicles, when in that situation; they are supplied by the same arteries in both sexes; and they sometimes descend, even in our own species, like the testicles, through the abdominal rings, as I lately showed you in an adult female (Goetlich), who exhibited here the androgynus condition of her sexual organs. They are sometimes partially connected with the fimbriæ of the end of the oviducts or fallopian tubes; they are covered with the fold of the peritoneum forming the broad ligament of the uterus; and they vary much in different quadrupeds, in the number and the extent of development, or the size of the ovules or Graafian vesicles which they present in the adult state, these being numerous and large in the monotrema, as in the ovaries of birds; fewer and smaller in the marsupialia, the edentata, and the rodentia, and perhaps the least and fewest in man. They have a lengthened narrow form in the human embryo, and in that of all the higher vertebrata, as they have in the adult state of cetacea, serpents, osseous fishes, and other inferior tribes.

Now we have seen the oviducts to continue distinct and separate organs from the ovaries in all the vertebrated tribes above the osseous fishes, and to remain for the most part as separate canals throughout their whole extent, although assuming distinct characters, and performing distinct functions, in different parts of their course. They still present this isolated form throughout their whole extent in many of the inferior mammalia, as the marsupialia, the monotrema, and some of the rodentia, where we commonly say that there is a divided uterus. The same detached form of the two lateral halves of the uterus is seen in the embryo of man, and of the animals which come nearest to him, and this embryo condition of the organ is sometimes preserved in our species, as a monstrosity, through life. The body of the uterus in the higher orders of mammalia is formed by the union, to a greater or less extent, of the lower ends of these two oviducts. When they are united only to a small extent below, they form two large cornua uteri above, leading to the narrow fallopian tubes, as we see in the ruminating and most of the other herbivorous quadrupeds, and to a less extent in the carnivora and other orders; and where they have united to a greater extent from below upwards, they form the triangular uterus of quadrumana, with acute angles, or the more rounded pyriform organ of the human body. The upper or ovarial end of the fallopian tube is generally wide, membranous, and funnel-shaped, like the infundibulum of the oviducts of birds, with margins more or less fimbriated, and attached at the upper edge to the ovarium. We have seen that the whole oviducts of the females are the analogues of the spermatic vessels of the males in oviparous animals, and the same analogies are obvious in these parts, whether they transmit an ovum with its chorion calcified on the surface, and thus isolated, as in birds and chelonia, or with its chorion soft and adhering, as in mammalia. The lower united portion of the oviducts forming the body of the uterus, corresponds, therefore, with the dilated vesiculæ seminales of the male, and the upper narrow convoluted portions of these oviducts, next to the ovarium, and forming the fallopian tubes, are supplied, not by the uterine, but by the spermatic arteries, like the epididymis of the male, and have been regarded as a dilated and shortened and uncoiled condition of that long and convoluted part. The ovarial opening of the fallopian tubes in the dolphin is as wide as the whole length of the ovarium, being about half a foot in diameter. The fallopian tubes are very long, narrow, and convoluted, like spermatic vessels, in many of the rodentia, as in hares, rabbits,

and guinea-pigs, thus showing that the sexual differences of the parts have been developed to a less extent in these inferior bird-like forms of quadrupeds, than they have arrived at in the higher orders.

The long narrow detached uteri of the monotrema, like their two ovaries, are unequally developed on the two sides of the body, that of the left side being, as in birds, larger and longer than the right, and with thick, glandular, and plicated internal parietes. They are wider at their two extremities than in their middle, and they open separately by prominent lateral papillæ into the common urethro-sexual canal or vagina, rather higher than the two openings of the ureters, as in birds and reptiles. This divided condition of the uterus, seen also in the marsupialia, appears to be there continued downwards through the upper portion of the vagina or urethro-sexual canal, so as to produce a bifurcated termination of that canal, corresponding with the reptile-like bifurcated form of the glans penis in the male. These parts preserve this divided form in the female kangaroo, notwithstanding the single termination of the glans penis in that animal. The vagina thus cleft at its upper part in the marsupial quadrupeds, retains its usual form and position in the monotrema, receiving the terminations of the divided uterus, as it receives the single os tincæ in higher mammalia. The gelatinous secretion common in the uteri of all the mammalia, and in the oviducts of inferior tribes, at the period of gestation, is formed in unusual abundance in the marsupial quadrupeds, closing the orifices of the uteri, and enveloping the attached umbilicated embryo in its ovum. In the half united or bicornate uteri of higher orders, we often find a single large ovum extending its long chorion nearly to the ends of both cornua uteri, and consequently requiring numerous placentæ or cotyledons in its course, while in more prolific tribes the two cornua uteri, long and convoluted like oviducts, are found to contain numerous ova attached by more circumscribed portions of their soft and deciduous chorion, and the surface of attachment of the ovum is still more limited in the concentrated triangular forms of the uterus with thick parietes, met with in many of the cheiroptera, quadrumana, and man. So that we trace the human uterus developing from its embryo state, or from the simplest oviparous form of the lower tribes, by the gradual shortening, and uniting, and thickening of two simple membranous oviducts.

The female organ of excitement is the clitoris, the analogue of the penis of the male, which here retains its embryo condition through life, as indicated both by its reptile-like form and its diminutive size. It is single in the highest mammalia, as in quadrumana and man, and bifid in the lowest, as in the monotrema and marsupialia, like the corresponding male organ in these different tribes. In many carnivora and rodentia, where the penis of the male is supported by an internal bone, the same osseous support is seen in the clitoris of the female, though in a rudimentary state. This organ, which is only partially developed, and often wanting in the reptiles and birds, is more constant in the mammalia, and is lodged in the anterior or prepucial part of the vagina. Like the penis of the male, it has a corpus cavernosum attached by a double root to the rami of the ischium; it has a small glans and a distinct prepuce; it receives the same artery, vein, and nerve, and the distribution of these is remarkably similar in the two sexes. Although it is open behind in most of the mammalia, on the side next to the urethra, and destitute of a corpus spongiosum, like the penis and the clitoris of a reptile, we find it tubular in the makis, and traversed by the urethra like their male organ. It is sometimes seen, as an abnormal character, so large in women, that the individual appears to possess both male and female parts, and can partially perform the functions of both, but completely neither, and this is the kind of hermaphrodism which we found so common as a normal structure in many invertebrated classes, where the clitoris was so large as to serve for copulation or for mutual excitement.

The openings of the genital and urinary passages we saw close to each other in the females, and also in the males, of oviparous vertebrata; they are still as close to each other in the vagina of the monotrema, and nearly as much approximated in that of the marsupial quadrupeds; but as we ascend through higher orders these two systems have their openings more separated from each other, and the vaginal space appropriated to the generative function is increased, till we find the urethra in the makis included in a distinct tubular clitoris, as in the penis of the male. The two small interrupted canals pointed out by Malpighi and by Gærtner, in many quadrupeds, running from the ovaries along the broad ligaments, and the cornua and body of the uterus, to open separately into the vagina at the sides of the urethra, have been shown by Rathke to be the remnants of two ducts pervious in the embryo, and leading from those remarkable deciduous renal bodies the *corpora Wolffiana*, which pre-

cede and form the first rudiments of the urinary and genital glands in the embryos of both sexes in all the higher vertebrata. The cloaca, which receives in the oviparous vertebrated classes all the excrementitious openings of the digestive, genital, and urinary systems, becomes gradually divided by the descent, posteriorly, of the rectal vestibule, to open upon the surface of the body by a distinct anal orifice, and the urethro-sexual canal is thus at length isolated from the rectal, as we ascend from the monotrema, and the rodentia and the edentata through the higher orders of quadrupeds. In the embryos of mammalia, as in the lower oviparous animals, not only are the genital organs alike in the two sexes, but the ovaries or the testicles and the kidneys arise from the same gelatinous mass, their ducts accompany each other, and open together into the same part of the cloacal termination of the intestine, so that these two great systems, so different in function, are almost repetitions of each other in their origin and structure. The most marked difference in the internal structure of the genital parts in the two sexes is the detachment of the fallopian tube from the ovarium, the separation of the duct from its gland, in the female, while the vas deferens remains continuous with the secreting tubuli of the testicle in the opposite sex, and this has been supposed to arise from the greater extent of separation which takes place between the two branches of the spermatic vessels in the embryo of the female than takes place in the male. This is a slight modification in the distribution of these common vessels, which many circumstances might easily induce at an early period of development, when all the parts are yet similar in the two sexes, and pliable to every modifying influence, and when all forms of monstrosities or abnormal formations are so easily and permanently produced.

The male genital organs of the mammalia present a greater development of the primary glandular parts, the testicles, and of the organ of excitement, the penis, than we find in the corresponding parts, the ovaries and the clitoris of the females, and these parts are also generally distinguished by a greater change of their primitive position in the body. The testicles, like the ovaries, originate in quadrupeds, as in birds and reptiles, from the inner parts of the long deciduous *corpora Wolffiana* or false kidneys of Rathke. These two long, fusiform, soft, deciduous glands, extend in the embryo along the whole of the back part of the abdominal cavity, from the heart to the pelvis; they are, next to the liver, the most vascular organs of the trunk, and give origin to the kidneys as well as to the genital glands. The long parallel testicles and kidneys of osseous fishes, extending along the sides of the vertebral column, retain through life the embryo form which they first present on being newly developed or detached from the inner sides of the two *corpora Wolffiana* in the next higher classes. These two genital and urinary glands in quadrupeds, however, quickly assume a more short and rounded form, and are seen already detached from the inner margins of the *corpora Wolffiana*, at the period of the closing of the last branchial openings of the neck. The penis and the clitoris are developed nearly at the same time with the testes and ovaria, and these sexual glands are earlier than the kidneys in their development. In the human embryo, before the closing of the branchial openings in the neck, the testes and the kidneys (without a trace of the supra-renal glands yet developed) are seen as long, narrow, parallel, cylindrical glands, extending longitudinally along the whole of the back part of the abdominal cavity, as in the adult state of osseous fishes, and they open at that time, close together, as in fishes, into the cloacal termination of the intestine. The testicles or ovaries of man, as those of quadrupeds, birds, and reptiles, have, at this early period, the kidneys extending along their median and dorsal margin, and the large *corpora Wolffiana* along their outer lateral margin. This primitive abdominal situation of the testes seen in all the adult oviparous vertebrata, and in the embryos of all the higher mammalia, is still permanently preserved in many of the lowest animals of this class, as in the cetacea and the monotrema; in others they descend, guided by the gubernaculum testis, to a variable extent, towards the abdominal ring, as in the seals and the walrus; in others they pass out through the abdominal ring only at the rutting season, to swell externally, and afterwards in their more collapsed state to be returned into the abdomen, as in numerous genera of burrowing rodentia; and in most of the higher orders of mammalia, as the carnivora, cheiroptera, quadrumana, and man, they pass down early into an inguinal scrotal cavity, and remain permanently external to the abdominal cavity. They come down earliest into this region in man, and we sometimes see the ovaries themselves descend through the abdominal ring in the human female, and lodge in the labia pudendi, thus forming a divided scrotum.

By the various positions of the testes,

we perceive that in the lowest tribes of animals nature has carefully provided for the safety of these important organs by retaining them within the abdomen, and has exposed them, for various reasons, on the surface of the trunk, only in the highest tribes, which have sagacity to protect them. The testes are composed of numerous minute, more or less convoluted, follicles or tubuli, as in the lower tribes of vertebrata, which converge from the periphery of the organs towards their interior margin, where they often form a reticulate plexus at the commencement of the epididymis, as in the human body. They differ chiefly in the extent to which the tubuli are divided and convoluted within the organ, the extent of the marginal reticulate portion formed by the vasa efferentia, and in the number and convolutions of the ducts forming the epididymis. They appear generally as if composed of a soft white parenchyma internally, from the interlacement and smallness of the component, convoluted, or tortuous tubuli, and from the soft white secretion which fills their cavities. The whole interior is supported by the firm cartilaginous radiating portions of the mediastinum. These tubuli seminiferi, composing the body of the testicles, become progressively more and more lengthened, tortuous, and convoluted, as we ascend through the vertebrated classes from fishes to man, and, like the tubuli uriniferi composing the mass of the kidneys, they preserve the same diameter, to their shut peripheral extremities, however long and convoluted they may be in their course. The number of convolutions formed by each single tubulus is sometimes so great as to give a minutely lobulated appearance to the surface of the testicles in this class; but in the inferior classes this lobulated appearance of the surface is produced by separate groups of tubuli, as in most other glandular organs. The tubuli seminiferi individually appear to be more minute and short, and they are more numerous in the lower classes of animals than in the higher; and their length and convolutions increase with their size as we ascend in the scale. They are remarkably small, short, and numerous, forming minute lobules in the testes of the rays and sharks; they are still very small, but long, in the testes of birds; they are observed to be much larger, longer, and more tortuous, in carnivorous quadrupeds, and in the rhinoceros, the hog, the cynocephali, and especially in some of the rodentia; and in man each lobule of the testes is composed of a single, long, tortuous, and convoluted seminiferous vessel or tubulus, uncoilable by maceration.

From the marginal retiform mass formed by the converging tubuli of the testes, pass out numerous vasa efferentia, which form by their tortuous convolutions the whole substance of the epididymis, and from the united trunks of the vasa efferentia in the epididymis is produced the single vas deferens which conveys the seminal fluid to the organ of intromission, through which it passes in all the mammalia by a distinct tubular canal, and not by a simple groove, as in the oviparous vertebrata. The epididymis thus formed by the vasa efferentia enlarges with them and their tubuli at the rutting season, especially in the inferior mammalia, which are more regular and periodical in this function than the higher tribes. The vas deferens, proceeding single and tortuous from the end of each epididymis, soon becomes more straight in its course and wider in its diameter as it proceeds to terminate in the commencement of the urethra, and in many of the pachyderma and ruminantia it forms an enlargement before opening into that canal. They open generally at a little distance from the neck of the bladder in a small recess of the urethra, protected by a fold of its mucous coat directed outwards, and the vesiculæ seminales open into the same part. These large receptacles of the male fluid, the vesiculæ seminales, are less important in the male than their analogue the uterus in the female, and are most irregular and inconstant in their existence and in their forms, being large reservoirs in many of the lowest quadrupeds, as the rodentia and the pachyderma, as well as in the higher orders of cheiroptera, quadrumana, and man, while they are wanting in many intermediate animals among the ruminantia, the monotrema, the marsupialia, and the carnivora. Cowper's glands are generally larger and more subdivided in the lower mammalia than in man. The prostate glands, commonly double, composed of many large branched follicles, and opening into the same part of the urethra with the seminal passages, are more constant in the mammalia than the vesiculæ, and though generally less connected than the vesiculæ with the product of the testicles, they have been considered as more like the analogue of the uterus. They sometimes appear as parts of the vesiculæ, and both together may represent the uterus. By the development of a corpus spongiosum in this highest vertebrated class the canal of the urethra is completely enclosed, and the open grooved male organ of intromission of the inferior oviparous tribes is here converted into a more perfect tubular penis. Its glans, formed by the corpus spongiosum,

is still often covered with sharp recurved horny spines, as we saw the extremity of this organ in reptiles, to retain its place during long copulation, especially where the vesiculæ seminales are wanting, and the urethra is often supported in these same animals by a grooved bone extending longitudinally through the organ. This organ is still spiny and bifid, and lodged in the cloaca in the ornithorhynchus, as in reptiles; it is bifid in many marsupialia, concealed in the cloaca in some rodentia, very large and concealed beneath the exterior parietes of the abdomen in the cetacea, suspended along the abdomen in the herbivorous and carnivorous quadrupeds, and hangs free in the cheiroptera and quadrumana, as in man.

Now, the product of conception in this class, the ovule or ovum, burst from the ovary, impregnated, and conveyed free, like a minute, soft, transparent hydatid, through the fallopian tube, is engrafted by its chorion into one or more points of the cornua or body of the uterus, where it is matured to a very variable extent in the different orders, and hatched in the act of expulsion, when the fœtus, naked, feeble, and helpless, requires the further process of lactation to complete its development, so far as to enable it to provide for itself. Many of the quadrumana and the cheiroptera are observed to menstruate periodically, like the human species, and F. Cuvier has observed the same in the genette among the carnivora. The mammary glands, thus forming a supplementary part of the generative system, begin their development, like other glands, by being simple follicles, cellular internally, opening by numerous minute excretory ducts, without papillæ in the monotrema, and with prominent sheathed nipples, placed beside the anus, in the blowing cetacea. These primary follicles become more subdivided, and their minute tubuli form internal lobes in higher orders, and, at length, in the highest mammalia, as in man, these tubuli become extremely minute in their subdivisions, commence in little vesicular dilatations at their shut extremities, are clustered into lobuli, and these into larger lobes, and open at the extremity of a prominent nipple, sometimes by a single excretory duct, as in the ruminantia, or by numerous orifices, as in most of the other mammalia. The position of these organs on the trunk depends much on the facility of access afforded to the young in lactation, being near the vagina in the predaceous cetacea, inclosed in the pouch of the abortive marsupialia, inguinal, or ventral, or ventro-thoracic in most of the horizontal quadrupeds, or pectoral in the more vertical forms of cheiroptera, quadrumana, and man, where the freedom and the flexibility of the arms enable them to manipulate and support the young, and for the same reason we see them thoracic in the herbivorous cetacea. The number of the nipples is regulated by the number of young which the parent is capable of producing at a birth, and they are generally two where the mammæ are thoracic. Thus, we observe that in this highest class of animals, where the whole organization is the most complicated and the most delicate, means are provided to retain the embryo in connexion with the parent, till it has arrived at a degree of development surpassing that of all the inferior tribes, and thus one generation becomes connected with another by ties of affection, which necessarily increase in strength as we ascend to man, whose helpless condition in infancy most requires their influence, and in whom they form a principal source of individual happiness and support, and the greatest bond of social union among families and nations.

Such then are the various organic systems which enter into the composition of animal bodies, and such appear to be the general laws which regulate their forms in the different tribes of animals. Notwithstanding the endless diversity which they present throughout the animal kingdom in their general forms, and in their separate details, we everywhere observe great simplicity and uniformity in the laws which regulate their forms, a perfect unity of plan in their composition and structure, and great regularity and harmony in the order of their developments. With a few simple earths, thrown out upon the surface, or diffused through the interior, or collected in the central parts, we see constructed all the different forms of the organs of support, and from nine vertebral elements all the complicated skeletons of the vertebrata. From the common animal matter of the hard parts, originate the various ligaments and organs of attachment; and from the simple irritable cellular tissue of the lowest tribes, are gradually developed the numerous strata and fasciculi of muscular fibres so admirably arranged and adapted for the various motions of the body, or of its separate parts. From globules of almost invisible minuteness, and neurilematous tubes, cylindrical or sacculated, are successively formed all the different kinds of nervous filaments, ganglia, and cerebral organs, so mysteriously connected with the motility and sensibility of animals, and with all their higher intellectual operations, and from the cutaneous covering of the body we see developed the organs of the senses,

placed at the extremities of sensitive nerves. The mucous lining of the alimentary cavity gives origin to the various glandular apparatus which open into its interior, and the superficial covering of the body to the cutaneous glands. From simple vessels we have traced the successive formation of the cavities of the heart, and the whole complex machinery of the vascular system, which gives origin to a respiratory organ, by seeking the influence of the surrounding element, in gills or lungs, a lacteal system by its extension to the intestine, and a lymphatic by reaching every point of the system. From the simple primitive cellular tissue of the body, we trace the formation of its cutaneous covering and the various forms of its epidermic exudations, and from the simplest fissiparous and gemmiparous forms of the generative system the gradation is not less regular and progressive, to the most complicated forms presented by the oviparous and viviparous classes. The transient forms of the organs in the higher classes of animals represent successively the permanent forms of the lower, and the laws of animal development have continued to operate with the same undeviating uniformity since the first appearance of animal forms on the earth, as we observe in those which govern the rest of the material world. So that while this interesting study relates to the most complicated forms of mechanism, and the most complicated phenomena to which the human mind has access, and constitutes the science of all organic structure and the philosophy of all anatomy, its discoveries, which unvail the most mysterious operations of nature, have all the evidence of physical science, and, like the sublime truths of astronomy, have all the permanence of that order and harmony which have been established from the beginning throughout the universe.

Yet one word, Gentlemen, before we part, touching the publication of these lectures in THE LANCET. The reports of them, drawn up by my able countryman and professional brother Mr. Macchristie, are executed with a fidelity, fulness, and accuracy, which are to me remarkable, when I consider the novelty of these studies in our scientific institutions, and how little they are generally understood by our medical men, and when I look to the innumerable technicalities with which these lectures are replete, and the intricate discussions into which they have often led us. Indeed, in looking over his reports, I cannot perceive that he has omitted a single sentence, and scarcely even a word, which I have spoken to you during this whole long course; a perfection in shorthand writing at which I had no conception that that most valuable art had yet arrived.

The engraved illustrations which accompany the printed lectures are due to the pencil of my intelligent and skilful pupil Mr. Townsend, who has frequently copied them from nature, and, considering his other academic studies, it must be acknowledged that they are executed with skill, judgment, and taste. I only regret that these oral demonstrations have not been more adequate to the importance of the subject, and the character of the work in which they appear, and more worthy of the expense and care with which they have been laid before the public.

When I mentioned to you, at the commencement of this course, Mr. Wakley's design to collect and print these lectures in the pages of his widely-circulated journal, I little anticipated that I could thereby have afforded occasion, even to the most ill-disposed persons, to wound the feelings of that gentleman. But I regret to find by the Medical Gazette of the 23rd of November last, that there have been some persons mean enough to make that simple announcement a pretext for harrowing up the feelings of Mr. Wakley by recalling assertions as false as they were malicious. It is ever the fate of independent journalists who stand aloof from selfish and servile ends, and criticise with equal severity the high and the low, to live in constant warfare, and to become the objects of watchful malice, jealousy, envy, and detraction.

These captious hirelings have found much fault with my applying the term "learned" to the Editor of THE LANCET, but I am confident that none capable of appreciating intellectual labour would refuse that appellation to one, who, by his own exertions, has done so much to spread and perpetuate medical information, which, without him, must have been lost to the profession and to science, and whose pen has never been at rest in exposing the defects of, or in suggesting improvements in, our medical institutions, in encouraging genius, in rewarding merit, in reproving the ignorant and the arrogant, and in forwarding the general interests of our profession. But, perhaps, this anonymous person of the Gazette would have thought Mr. Wakley more worthy of such a title had his claims to it been founded on the discovery of a universal antidote in a "*Pilula ex mica panis*," or some equally efficacious nostrum of an ignorant quack.

Every low epithet of scurrility and abuse, not excepting even those of "falsehood," "forgery," and "blasphemy," has,

in these anonymous articles of the Gazette, been wantonly vented against the Editor of THE LANCET, whose publication it is said I commended to my class, in consequence of my vanity being gratified by the manner in which my name has been mentioned in some of the advertisements of THE LANCET; and the same impudent menials have accused me of entering into a secret compact with Mr. Wakley to puff this University.

You will ever observe that the keen edge of satire falls harmless, and turns back upon itself, when tempered with such rudeness and vulgarity: just criticism shuns the heat of malice and vituperation, which evaporates its true spirit. I regret to say that I have seen that highly-talented and learned gentleman but once in my life, and I have never had a word of written correspondence with him on that or any subject whatever. The other statements and insinuations relating to me in that Gazette, are equally false and impertinent. I have never been guilty of courting the praise or shunning the criticism of any journal. A *lancet* which is in constant employment must inflict many a wound, but if it be guided even with moderate skill and judgment, those whom it cuts must be benefited by the bleeding. The best criterion of the merits of a public journal, I have ever considered to be the opinion and support of the public; and the long-continued and vast circulation of THE LANCET is the best testimonial of the estimation in which it is held among medical men. Had that journal been the production of some servile minions, hired to forward the ends of private interest, or party spirit, or corrupt monopolies, or place-hunting adventurers, and to slander systematically the rising and liberal institutions of their country, it must long since have sunk, by exciting the contempt and disgust of all sensible men, or it would now have lingered on a miserable existence, prolonged only by the precarious gleanings of its slander, detraction, and falsehood. THE LANCET, every one knows, was commenced and is conducted by a private surgeon, and it presents a phenomenon perhaps unique in the history of our literature,—of an extensive weekly periodical, devoted to one department of science, which is confessed, even by its enemies, to spare no man, and to have no patron among the "great," and which yet for ten long years has fought its own battles for the diffusion of useful medical knowledge and the reform of medical abuses, and with so much success, that now, when its greatest victory is in prospect, our public bodies seem to vie with each other in their endeavours to accomplish its objects, and to rob that journal of the glory of its conquests.

With these remarks, so foreign to our proper subject that I beg you to excuse my introducing them, I conclude the present course, and wish you all success in your future pursuits, and much happiness and usefulness in your professional career.

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